W. B. No. 852

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CONTENTS

WEATHER OF THE MONTH

CHARTS

CORRECTIONS

REVIEW, March, 1924:

Page 182, table of flood stages, under the caption WEST GULF DRAINAGE following the entry for the Sabine River, insert these data:

Neches: Rockland, Tex.	22	2	2	26.6	2

REVIEW, September, 1924:

Page 437, section VIII, fifth line, for "one year apart," read "six months apart."

Page 455, figure 4, right margin figures should be increased by 0.5 year.

Page 459, first column, third paragraph, seventh line, the word "October" should read "September."

REVIEW, October, page 488, in figure 1, symbols to accompany the legend are as follows:

○ ⊙ Weber, Comm. Phys. Lab. Leyden, No. 150, 37 (1915).

● Scheel and Heuse, Ann. Physik, **29**, 731 (1909).

▣ Scheel and Heuse, revised by Holborn, Scheel and Henning.

△ Drucker, Jimeno and Kangro, Z. Phys. Chem., **90**, 529 (1915).

† In marine separate.

MONTHLY WEATHER REVIEW

ALFRED J. HENRY, Editor

Vol. 52, No. 11
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NOVEMBER, 1924

CLOSED JANUARY 3, 1925
ISSUED FEBRUARY 2, 1925

AN ANALYSIS OF A RETROGRADE DEPRESSION IN THE EASTERN UNITED STATES OF AMERICA

By J. BJERKNES, Bergen, Norway, and M. A. GIBLETT, London, England

The present investigation was carried out during a brief visit of the writers to the United States Weather Bureau, Washington, in the late summer of 1924. A study of the working charts in the forecast division of the Bureau suggested that a detailed examination of specially selected cases would yield interesting results, especially as the Weather Bureau possesses a very complete set of autographic records of meteorological elements at a great number of stations. The investigation of the present case was rendered possible through the courtesy and assistance of Dr. C. F. Marvin, chief of bureau, and of members of his staff, to whom we wish at once to express our gratitude.

The depression of October 22–25, 1923, was selected as it represented an interesting case of a retrograde depression, or one which had a westward component in its motion. Such systems are comparatively rare in Europe, and they are extremely rare in the northeastern United States. This paper contains no new theory, but the results of the investigation are satisfactory in that they show that an American retrograde depression exhibits the same structure as is familiar in the case of the European ones.

The situation during the early stages of the depression is given by the two maps in Figures 1 and 2. The first of these shows two anticyclones, a cold continental one centered over the northern United States, and a warm one centered over the ocean east of Bermuda. A long, narrow trough of relatively lower pressure lies between them, some 300 miles off the coast. The lowest pressure in this trough, 1,007 millibars, is found at Nassau, in the Bahamas. The trough is seen to mark a sharply defined limit between two distinct air currents. On the eastern side is a warm southerly current of evident tropical origin, with a fairly homogeneous temperature, in most places above that of the sea. On the other side, there is a colder northeasterly current originating beyond the northern boundary of the chart. The temperature in this current increases toward the south as the air passes over warmer and warmer water, but it has the usual characteristic of the temperature of "polar air" moving southward in that it remains everywhere below that of the sea. Even in the extreme south it shows a deficit of as much as 7° or 8° F. Throughout the tropical current the weather is generally fair, even close to the trough, whereas on the other side of the discontinuity the sky is uniformly overcast for a distance of about 400 miles, and rain is falling in a zone 200 to 300 miles broad, extending from Florida to Nova Scotia. We have here a case of approximate equilibrium between two adjacent counter-currents separated by an inclined plane sloping upward over the colder air at an angle with the ground, which is given by the classical formula of Margules.[1] The occurrence of precipitation in a continuous band on the cold side of the discontinuity shows, however, that the warm air is already mounting the inclined plane above the cold air, representing a first departure from equilibrium conditions.

The chart for the next morning, Figure 2, shows that 24 hours later the discontinuity has become distorted, the portion between latitudes 32° north and 39° north having advanced about 150 miles towards the coast. In the field of pressure, this appears as the formation of an elongated depression with its center in about latitude 33° north at the sharpest bend in the discontinuity. The barometric pressure in the center is 1,000 millibars, lower than any pressure on the previous chart, so that we have here the phenomenon of the development of a depression on a *preexisting* discontinuity between adjacent warm and cold air masses. The deepening of the depression has synchronized with increasing wind velocities, Beaufort force 11 being reported by one ship off Cape May, N. J. The depression has a well-defined "warm sector" which has only broken skies and no rain, except close to the center. On the other hand, the cold portion continues to have an extensive rain area, now of characteristic form, broad north of the center where the discontinuity behaves as a "warm front," and narrower to the south where it takes on the character of a "cold front."[2]

The further history of the system has been traced in much more detail by the close study of autographic records of wind, temperature, pressure, sunshine and rainfall from the complete network of land stations, particularly by hourly weather charts constructed from these records. While this was necessary for the complete diagnosis of the case, it is impossible to reproduce all these maps and registrations in this brief account. A selection has accordingly been made, comprising the four maps in Figure 3, for the epochs October 23, 8 p. m. (75th meridian time), October 24, 8 a. m., and 8 p. m., October 25, 8 a. m., and registrations at 18 stations in Figure 5.

On the first chart of Figure 3, for the evening of October 23, the center has just crossed the coast and is to be found a little to the north of Norfolk, Va. The temperature at Cape Henry, just to the east of the center is 65° F., showing the arrival of the tropical air, which has, however, been chilled somewhat by contact with the colder coastal waters.

On the morning map for October 24, the center of the depression is on the point of passing the Alleghenies, in the well-known way of crossing a mountain range by developing a new center on the further side, while the original center decays. The tropical air can now no

[1] Margules. Hann-Band der Met. Zeitschr. 1906. p. 293.
[2] J. Bjerknes and H. Solberg. Geofysiske Publikationer, Vol. III., No. 1, Kristiania, 1922. (Abstract in Monthly Weather Rev., Sept., 1922)

longer be regarded as extending to the center of the depression, but only to the vicinity of New York. Between New York and the center of the system the tropical air is occluded, in other words lifted completely off the surface between the cold air arriving from the northeast and a branch of the same air mass, which has had time to curve round the depression and arrive back, from the south. This view is supported by the construction of the trajectories of air masses in different parts of the depression. (See fig. 4.) In doing this work the hourly maps referred to above were brought into use. Taking the air mass at New Haven on the morning of the 24th with a temperature of 50° F. and tracing it back, it is found to have entered the depression from the region of Nova Scotia, thus being of a cold origin. The air mass over Sandy Hook on the morning of the same day has a temperature of 60° F. and may nevertheless be traced back to a similar northern source. It has, however, in the meantime, traversed a curved path, encircling the center of the depression and leading down to latitude 37° before recurving. This offers more opportunity for the air to become warmed than is the case for the first

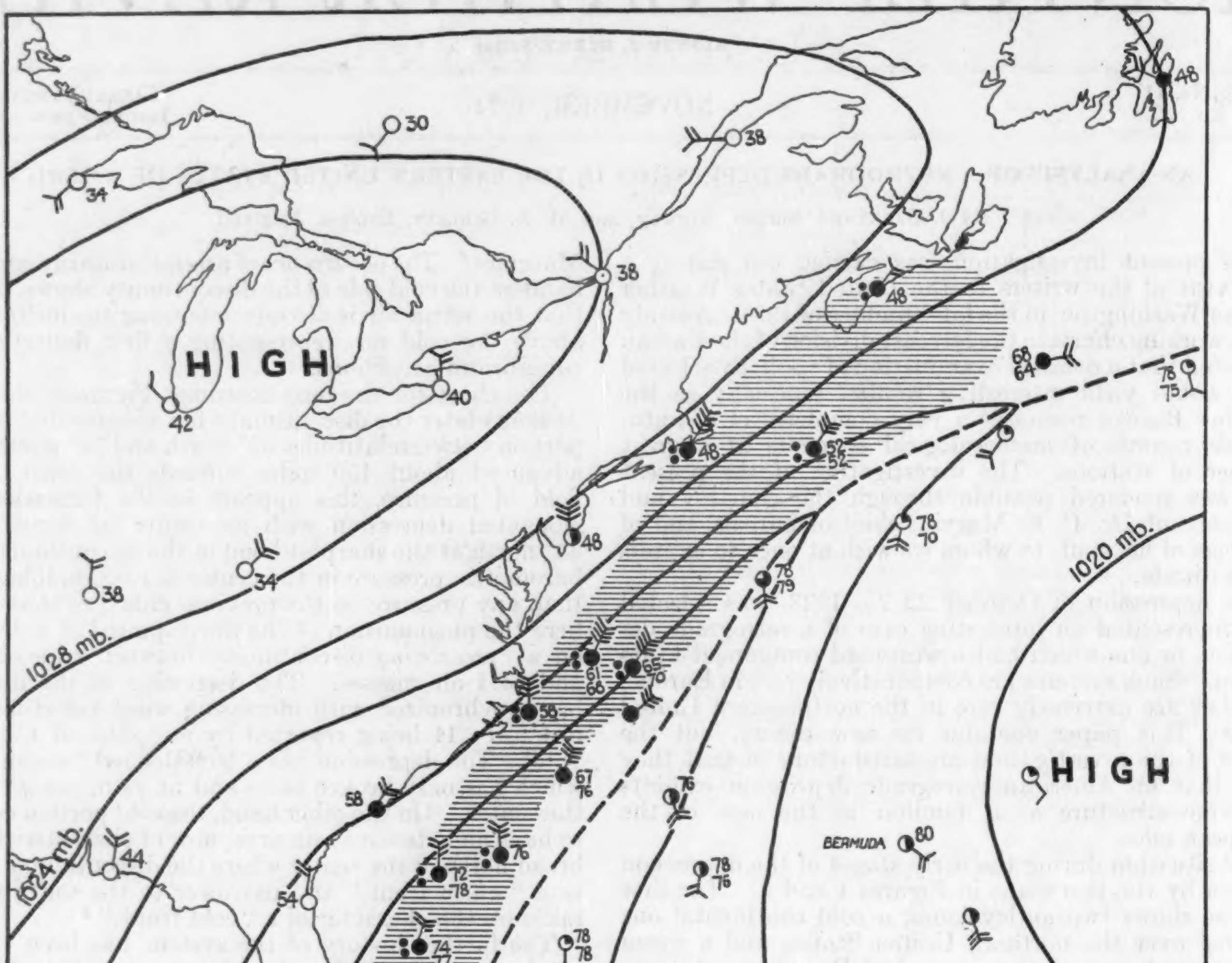

FIG. 1.—Map showing conditions during early stage of depression. (In this and later figures the following symbols are used: The Beaufort force of the wind is indicated by the number of feathers on the arrows; the amount of sky covered by cloud is given by the fraction of the circles shaded; precipitation at a station is shown by two dots; areas where precipitation is taking place are shaded; figures indicate temperatures in degrees F., and where, in the case of ships, two are given together, the lower refers to the sea; "warm fronts" are indicated by lines composed of dashes and "cold fronts" by lines composed of dots.)

path considered. The observed contrast of temperature along the occluded portion of the "front" is thus quite natural. It is, however, interesting to remark that nearer the center the circulating air is not carried so far south, so that the contrast diminishes. (The southeast wind at Harrisburg, Figure 3b, has a temperature of only 52° F.). The third trajectory of Figure 4, shows the path of the air mass arriving at Block Island at the same time as the masses already considered arrive at New Haven and Sandy Hook. This trajectory leads directly back to the tropical current in the region of Bermuda, thus defining the air of Block Island as belonging, without any doubt, to the "warm sector" of the depression, although its temperature of 60° F. is not higher than that of Sandy Hook. The presence of fog at Block Island is here significant and is consistent with the southern origin of the air. The latter, in passing northwards, has been cooled below its dewpoint on reaching the rather cold water near the coast. The average October water temperature in this vicinity is 59° F., and in November the temperature is already down to 53° F., so that at the date in question it must be about 57° F.

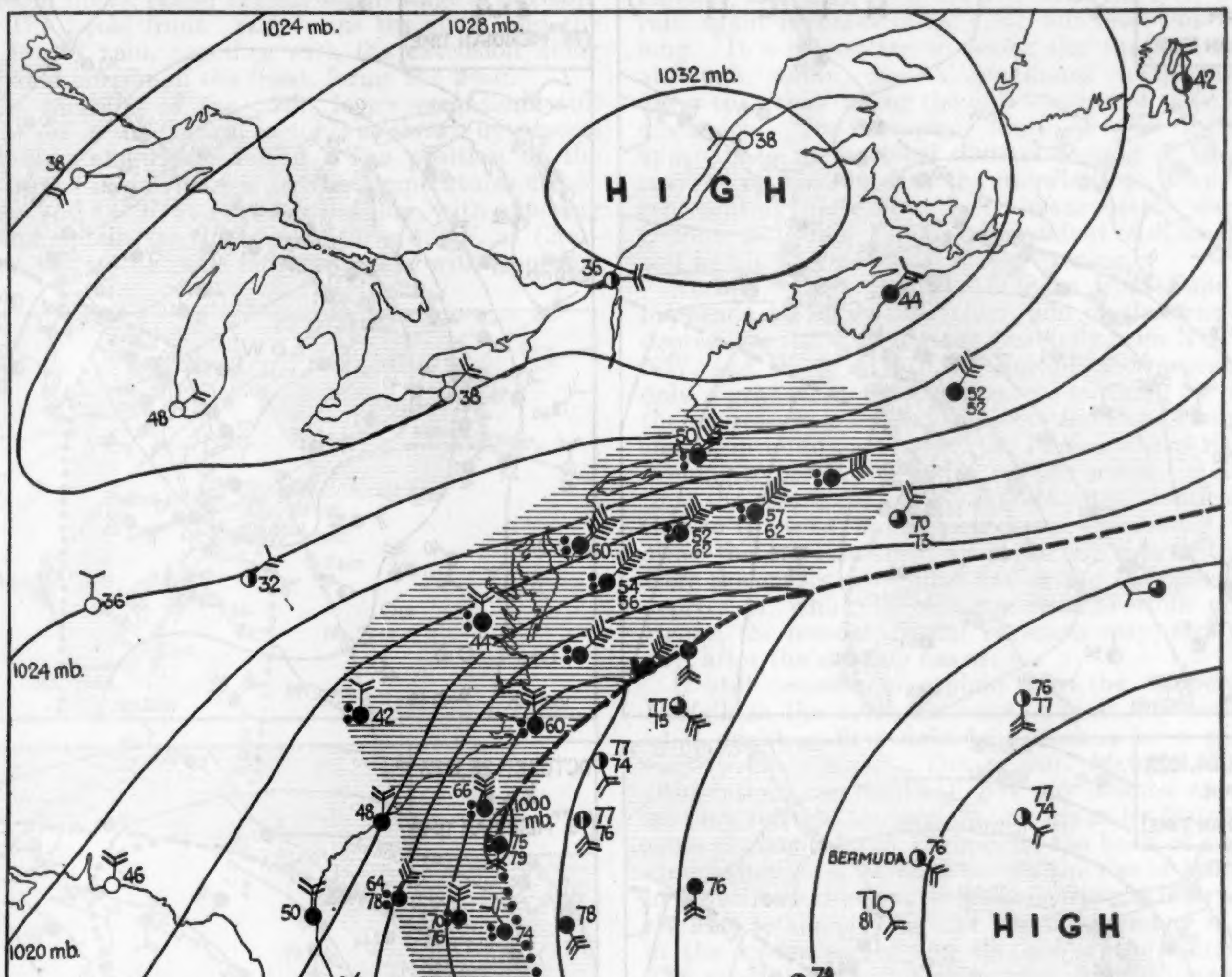

FIG. 2.—Map showing depression during course of development

This cooling of the air must necessarily be confined to a shallow surface layer. Above the cooled layer the original temperature of the tropical current must persist,

apart from slow changes by radiation effects. It will be seen later, when the registrations are discussed, that the cooled layer is so thin as to be readily destroyed by some hours' sunshine. The presence of this cooled layer has

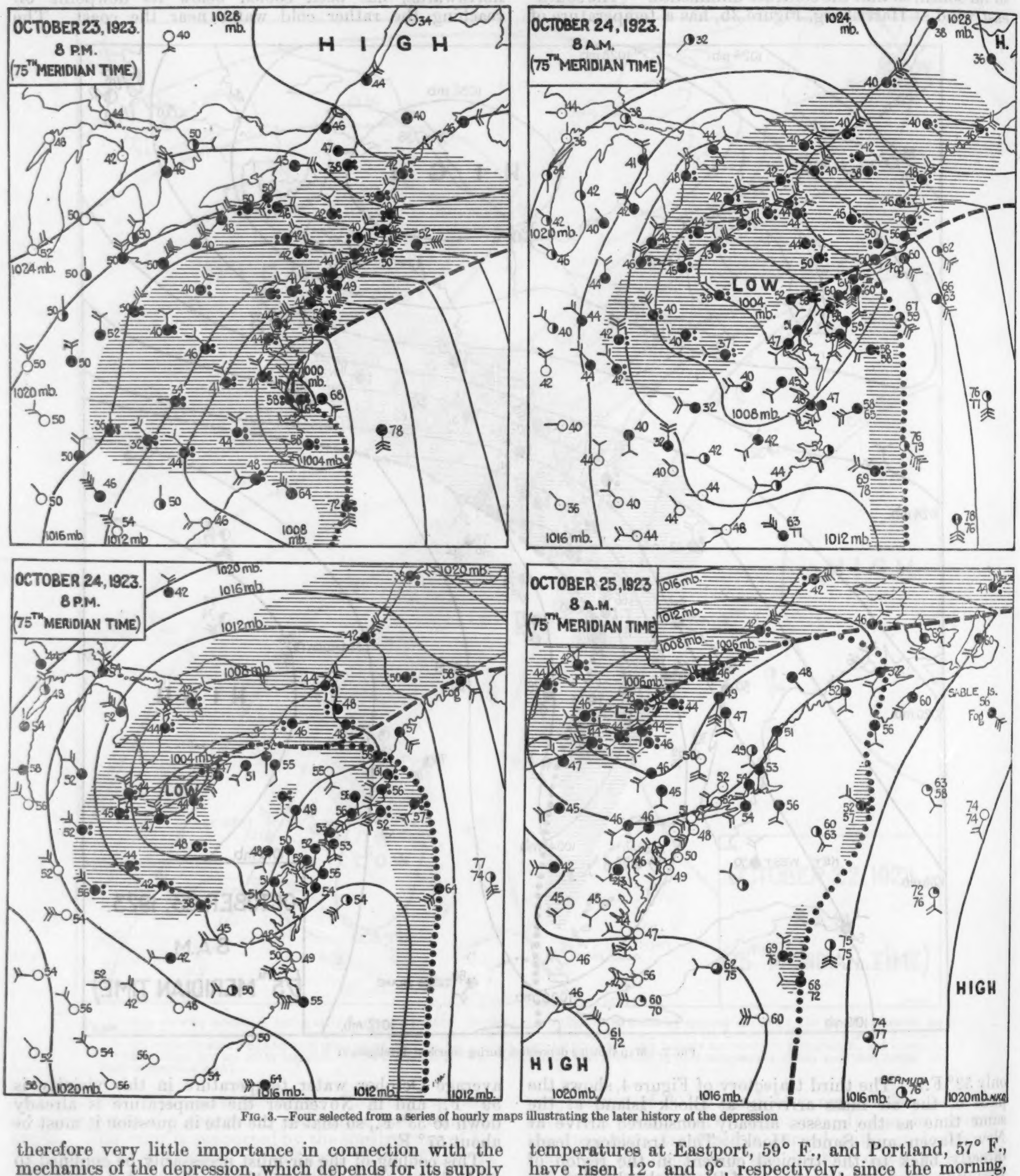

FIG. 3.—Four selected from a series of hourly maps illustrating the later history of the depression

therefore very little importance in connection with the mechanics of the depression, which depends for its supply of energy upon temperature contrasts between air masses of great vertical extent. Such effects as this must be allowed for in analyzing a situation from surface data alone, since they mask conditions in the upper air.

The evening map for October 24 shows the arrival of the foggy tropical current on the coast of Maine. The temperatures at Eastport, 59° F., and Portland, 57° F., have risen 12° and 9°, respectively, since the morning, with the passage of the "warm front." A rise in the surface temperature beyond these figures is checked by

the presence of cold water, the average temperature of which is about 52° F. at this period of the year. The relatively colder current from the southwest has advanced past Nantucket, and the "cold front" now lies almost wholly over the sea.

The rain area assumes on this, as on the previous chart, a mushroom shape, rather typical of this stage of development. The "cold front" rain forms the stalk, and the "warm front" rain, together with the extension along the occluded portion of the front, forms the head.

On the morning of the 25th, foggy conditions still prevail at sea in the "warm sector," as shown by reports from Halifax and Sable Island. The position of the "warm front" is well defined by the temperatures 60° F. at Sydney and 44° F. at Port aux Basques, with opposing winds, and equally by the temperatures 62° F. at Charlottetown and 46° F. at Chatham, again with opposing

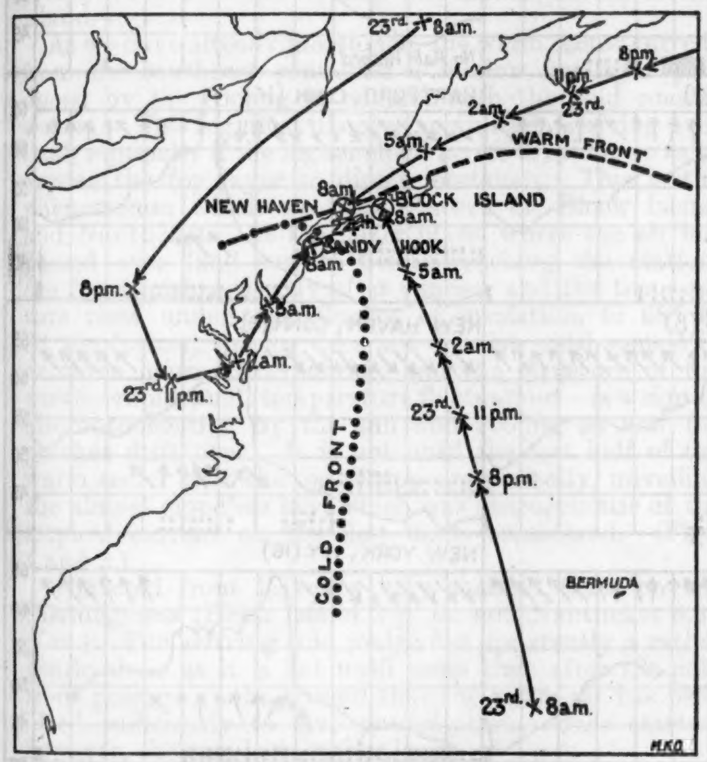

Fig. 4.—Diagram showing the trajectories of the air masses which arrived at New Haven, Sandy Hook, and Block Island at 8 a. m. October 24, 1923

winds. The "cold front" has, during the night, advanced from Nantucket to the western point of Nova Scotia. In the southern part, south of latitude 40°, the front has become almost stationary, the cold air tending to spread out laterally north and south instead of advancing east. Conditions are now favorable for the formation of a new depression on the reestablished stationary front, and the southernmost part of all seems already to retire again in a westward direction as a "warm front." Along the portion of the front over the ocean the rain area is apparently breaking up.

Passing now to the conditions at individual stations, these are represented in graphical form in Figure 5. The stations are arranged in three columns, each column corresponding to one of the dotted lines on the inset map and giving a section across the track of the depression. Let us consider first the stations in the first column, passed by the depression when at maximum development. The thermogram for Cape Henry exhibits a very clearly defined "warm sector" from 6 to 9 p. m. on October 23. The diagram also shows that before this period the wind is NE., during the warm interval it is from a southerly point, and finally becomes SW. when the "cold front" arrives. It is also seen that continuous rain falls while the wind is NE., that in the "warm sector" there is only a trace of rain, not sufficient to register, and that, with the arrival of the SW. wind, the rain again becomes measurable but does not last very long. It is interesting to notice also that the next day, although sunny, has a maximum temperature 10° lower than that during the dull weather of the day under discussion. The rounded form of the thermogram appropriate to the local diurnal heating of October 24 may be contrasted with the more abrupt shape of that representing the advectively transported warmth of October 23, which is quite independent of diurnal effects, and in this case occurred in the evening.

Norfolk, which is only 16 miles from Cape Henry, happened to be on the other side of the track of the depression, the wind turning gradually from NE. through NW. and W. to SW. The Norfolk thermogram shows only a gradual rise of temperature reaching 58° F. when the depression is nearest, whereas the Cape Henry curve shows, in addition to this, the further sharp rise in the evening to 65° F. due to the "warm sector." After this time the thermograms are again almost identical. Further to the west, at Richmond and Lynchburg, we have other thermograms typical of the left side of the track. Here the curves are almost flat during the passage of the depression, while, in common with Norfolk and Cape Henry, the normal diurnal variation reappears the next day, after the clearing has set in.

It still remains to explain why the temperature at Norfolk in the northeast current gradually rose, giving what might at first sight be mistaken for a passage of the "warm sector." The present material of surface observations can not itself give any definite answer, but we may refer to the explanation given by Stüve [3] of the same phenomenon in Europe, on the basis of aerological observations. According to him the rise of temperature in the cold air adjacent to the discontinuity is an adiabatic rise due to the sinking and lateral spreading of this air in the wedge underlying the air of the warm sector. The general type of thermogram for the passage of a "warm front" is, accordingly, a gradual slow rise of temperature followed in most cases by a discontinuous upward jump. Cape Henry is of this type, a part of the gradual rise coming, however, before 8 a. m. on October 23, and so not being shown in the diagram. Much more striking examples are given by Boston, Hartford, New Haven, etc. In the case of a station slightly to the left of the track of the depression the gradual rise appears without the further "warm sector" rise. This is exemplified by Norfolk, and, less strikingly, by Washington. Stations more remote from the track on the left-hand side do not come within the range of the adiabatic warming effect at all.

Following the coast stations northward, we find that Atlantic City and Sandy Hook have thermograms very similar to that of Cape Henry, and even the maximum temperature arrived at within the "warm sector" is the same within one degree, although this maximum occurred in the evening at Cape Henry, during the night at Atlantic City, and in the morning at Sandy Hook. Baltimore, nearer to the track of the depression, has a very short period of high temperature, reaching a sharp

[3] "Aerologische Untersuchungen zum Zwecke der Wetterdiagnose" Die Arbeiten der Preussischen Aeronautischen Observatoriums XIV Band, 1922.

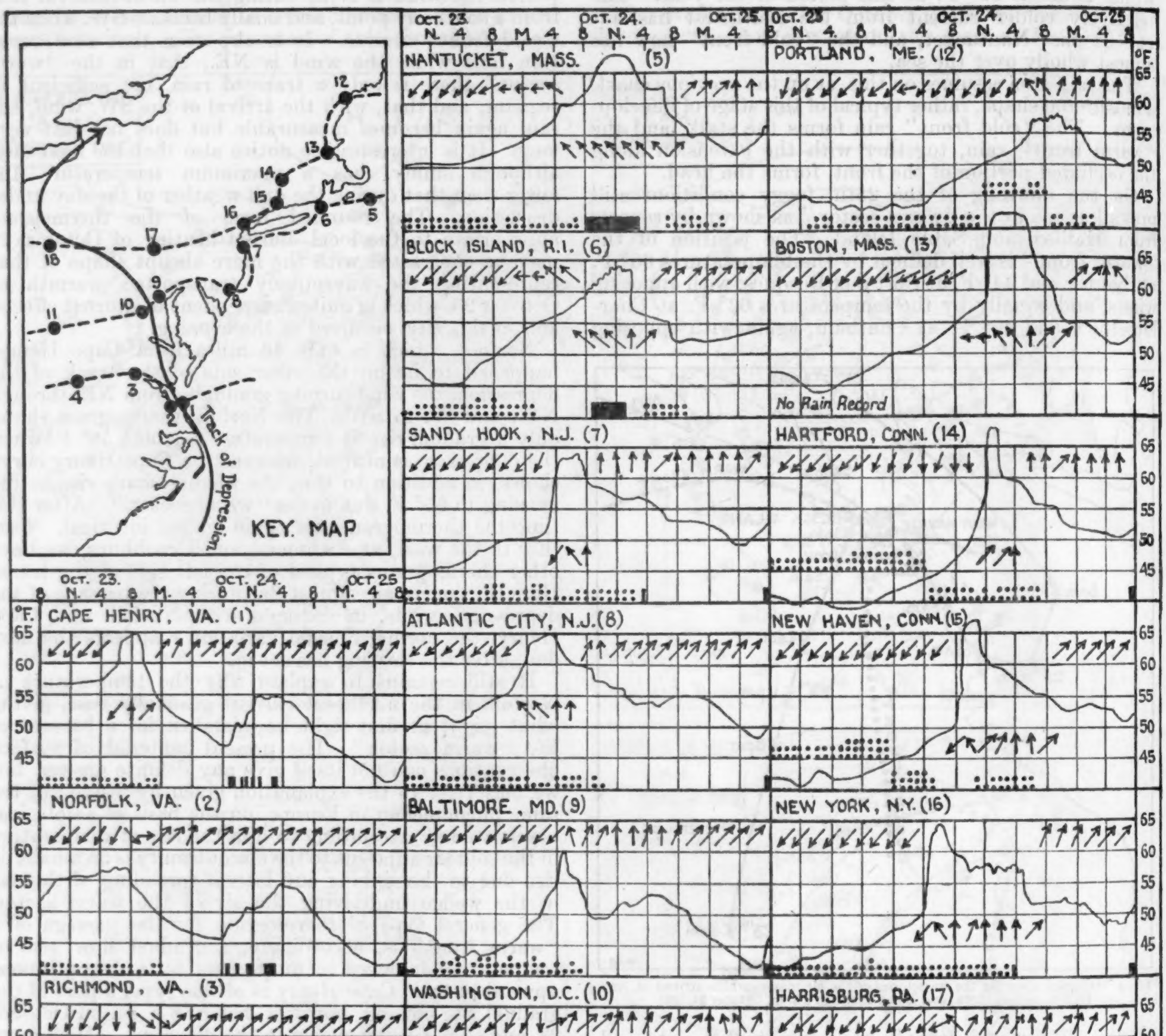

FIG. 5.—Diagram prepared from the autographic records at 18 selected stations in the area under consideration. (The arrows show the wind direction at intervals of two hours. The dots indicate the rainfall during the preceding hour, one dot meaning a trace only, two dots amounts up to 0.20 inch, three dots amounts of 0.20 inch or above. Periods of sunshine are indicated by black areas on the same horizontal line as the rainfall. The numbers placed after the station names correspond to the inset key map.)

maximum of but 60° F. This evidently represents the type of thermogram which must be obtained during the transition to an "occlusion," when the warm sector is on the point of disappearing from the surface. The sharp maximum in the Baltimore thermogram is entirely absent from the Washington record obtained less than 40 miles away, but on the other side of the track, while the other portions of the curve are very similar at both places.

The longest duration of the "warm sector" is to be found on the two stations Block Island (4 a. m.–2 p. m.) and Nantucket (4 a. m.–6 p. m.). Although situated not more than 80 miles apart, these two stations have rather different thermograms during the time the warm sector passes. This may, however, be accounted for when considering the local conditions at both stations. Whereas the station at Block Island is situated on a very small island, Nantucket lies on a larger one, and—what is in this case of special importance—on the northwestern side of the island.

As we have already mentioned, the warm sector current from the southeast contained a shallow fog layer produced by the cooling in contact with the cold coastal waters. This fog must dissolve again when arriving over land, especially if the higher cloud layers break up so as to expose the fog layer to direct insolation. This is the phenomenon which we may observe on Block Island and Nantucket. At the latter place, where the air has passed over land surface before reaching the station, the fog vanishes shortly after sunrise, and the temperature rises, under the influence of insolation, to 68° F. At the former, the fog does not dissolve until some two or three hours after sunrise, and the structure of the curve—rapid small temperature fluctuations—is a sign of alternate heating by the sun and cooling as new fog patches drift over. It is not until the last half of the warm sector that the fog disappears perfectly, unveiling the almost cloudless sky, which was characteristic of the tropical current on the first maps considered. (Figs. 1 and 2.)

The cold front leaves a very marked trace on the thermograms (Block Island 2 p. m. and Nantucket 6.30 p. m.). The arriving cold wedge has apparently a rather gentle slope as it is not until some time after the cold front passage at the ground that the warm air has been lifted sufficiently to give precipitation. Once started, however, the rain lasts rather long.

Boston, Hartford, New Haven, and New York provide good examples of thermograms with the passage of a "warm sector," the maximum temperatures reaching (partly assisted by the diurnal effects) 70° F., 68° F., 67° F., and 65° F., respectively. Portland represents the same type with, however, a markedly depreciated warm sector temperature on account of the fog. Harrisburg represents the type of thermogram to be expected at the place where the warm sector air has just been lifted away from the ground, and Pittsburgh (on the western side of the track) shows the presence of rather uniformly cold air during the whole cyclone passage.

The complete mechanism of the depression in all layers, the rules for its growth, propagation, etc., can of course not be analyzed without an additional aerological diagnosis. In the absence of adequate information of this kind we must confine our attention to the conclusions as to the mechanism of our retrograde depression which may be drawn merely from surface observations. The results, which may seem partly hypothetical, receive, however, additional support from their concordance with those of numerous other cases.

The movement of the depression, although surprising when considered in relation to average tracks, appears quite normal when it is seen in relation to its thermal structure. The motion of the center is, at each moment, approximately parallel to the instantaneous direction of the warm current. It is this current which decides the displacement of the extremity of the warm tongue where the lowest pressure is located. The warm current in the present case is originally from almost due south, but later acquires a component from the east, at the time when the depression curves toward the northwest. (See track, fig. 5.)

The depression continues its northwestward propagation also after the warm air has been lifted off the ground, probably governed by the southeast current of a still existing "upper warm sector." This view is also confirmed by the fact that the upper clouds in front of the depression were moving from southeast. From the moment when the warm air nearest the center is lifted away from the ground the depression begins to fill up, being from now deprived of the supply of potential energy—in the form of temperature contrasts—for the maintenance of its kinetic energy. Farther east, where the "warm sector" still exists, potential energy is still available and gives rise to the formation of a secondary depression. The first sign of it is to be seen on Figure 3b in the region of New York, at the extremity of the warm tongue. The formation is more accentuated the next day over northern Massachusetts and reaches finally the stage of an independent center between Montreal and Quebec on the morning of the 25th. This center from now on becomes the main one, and the dying "mother cyclone" over Lake Ontario behaves as a secondary, while they both move off the map toward Labrador.

VARIATION IN SOLAR RADIATION INTENSITIES MEASURED AT THE SURFACE OF THE EARTH

By HERBERT H. KIMBALL

[Weather Bureau, Washington, Dec. 1924]

This paper brings up to date a communication on the same subject published in 1918.[1] For the years previous to 1901 no additional data are available. Revised data have been obtained for Warsaw, Poland, for the years 1901 to 1918, inclusive. Data have been added from Kew Observatory, England, for the years 1908 to 1921, inclusive, and from Helwan Observatory, Egypt, for the years 1914 to 1923, inclusive. The data for Washington, D. C., Madison, Wis., and Lincoln, Nebr., have been revised and brought down to the end of 1923. That for Santa Fe, N. Mex., ended with March, 1922.

In Table 1 there are given for each station the month and year of the beginning and ending of the record, and reference to a footnote giving the character of the data that have been made use of in this paper. In the previous paper it was noted that some of the records were fragmentary in character. There has been improvement in this respect in the records of later years.

The monthly normals of the solar radiation intensities for Kew Observatory and also for stations in the United

[1] Kimball, Herbert H., Volcanic eruptions and solar radiation intensities. Mo. WEATHER REV., AUGUST, 1918, 46: 355-356.

States have been obtained by dividing the sum of all the radiation intensities measured in the respective months by the number of measurements. The normal monthly maxima of radiation have also been obtained in this way. All other monthly normals are averages of the monthly means for the respective months.

TABLE 2.—*Duration and character of solar radiation intensity records*

Year	Montpellier, France	Pavlovsk, Russia	Lausanne, Switzerland	Warsaw, Poland	Washington, D.C.	Simla, India	Paris, France	Mount Weather, Va.	Kew Observatory, England	Madison, Wis.	Santa Fe, N. Mex.	Helwan Observatory, Egypt	Lincoln, Nebr.	Total number of stations
1882	Dec.													1
1883	x													1
1884	x													1
1885	x													1
1886	x													1
1887	x													1
1888	x													1
1889	x													1
1890	x													1
1891	x													1
1892	x	Sept.												2
1893	x	+												2
1894	x	+												2
1895	x	+												2
1896	x	+	Jan.											3
1897	x	+	x											3
1898	x	+	x											3
1899	x	+	x											3
1900	Dec.	+	x											3
1901		+	x	Jan.										3
1902		+	x	+										3
1903		+	x	+										3
1904		+	Aug.	+										3
1905		+		+	June.									3
1906		+		+	o	Oct.								4
1907		+		+	o	x	Jan.	Sept.						6
1908		+		+	o	x	+	o	Jan.					7
1909		+		+	o	x	+	o	#					7
1910		+		+	o	x	+	o	#	July				8
1911		+		+	Aug.	x	+	o	#	o				8
1912		+		+		x	+	o	#	o	Oct.			8
1913		Apr.		+		x	Dec.	o	#	o	o			8
1914				+	Oct.	x		Sept.	#	o	o	Feb.		8
1915				+	o	Dec.			#	o	o	*	July.	8
1916				+	o				#	o	o	*	o	7
1917				+	o				#	o	o	*	o	7
1918				Dec.	o				#	o	o	*	o	7
1919					o				#	o	o	*	o	6
1920					o				#	o	o	*	o	6
1921					o				Dce.	o	o	*	o	6
1922					o					o	Mar.	*	o	5
1923					o					o		*	o	4

x Monthly mean of noon solar radiation intensity.
\+ Monthly maximum of solar radiation intensity.
o Monthly mean of solar radiation intensity with the sun at zenith distance 60°.
* Monthly mean of solar radiation intensity with the sun at zenith distance 54°.
\# Average of monthly maximum and monthly mean of noon solar radiation intensity.

The monthly means or the monthly maxima of radiation for the different stations have been expressed as a percentage of their respective normals. Then for each month an average of these percentages has been computed, and smoothed by the formula $\frac{a+2b+c}{4}$, where b is the average percentage for the month in question, and a and c are the average percentages for the preceding and following months, respectively. The smoothed percentages have been plotted in Figure 1.

In the previous paper attention was invited to the fact that in the record for the earlier years, when data were available for only one or two stations, the plotted monthly values are somewhat scattered. As the number of stations increases, the difference between successive monthly values becomes markedly less, and it is possible to draw a free-hand curve that represents the variations in the smoothed monthly values fairly well. This has also been done for the earlier years but with less satisfactory results. It is thought that the available data do not justify a closer graphical representation than is given by this free-hand curve.

The main features of this curve—namely, the three great depressions following volcanic eruptions, Kratatoa in 1883, Pelée, Santa Maria and Colima, in 1902, and Katmai in 1912—are practically the same as shown in the previous paper. This is also true of the two minor depressions in 1888–9, and 1907–8. The curve has been modified to coincide more closely with the low values for December, 1890, to March, 1891, inclusive, and the depression shown in 1917–18 has disappeared, as was anticipated it might do when data from additional and more widely scattered stations were received.

From July, 1914, to the end of 1923 the plotted monthly values show little variation, the extremes being 97 and 105. During the same period the annual mean values vary between 100 and 101. Since the beginning of systematic pyrheliometric measurements in December, 1882, the only period comparable with the above in the uniformity of the radiation intensities is from September, 1892, to October, 1902, inclusive, or the 10 years preceding the volcanic eruptions of 1902.

There is a slight depression in the plotted monthly values between October, 1920, and March, 1921, or about at the beginning of the depression in Abbot's[2] published values of the solar constant. The depression does not persist as does the depression in Abbot's values, however.

The following are the sources of the radiation data that have been utilized:

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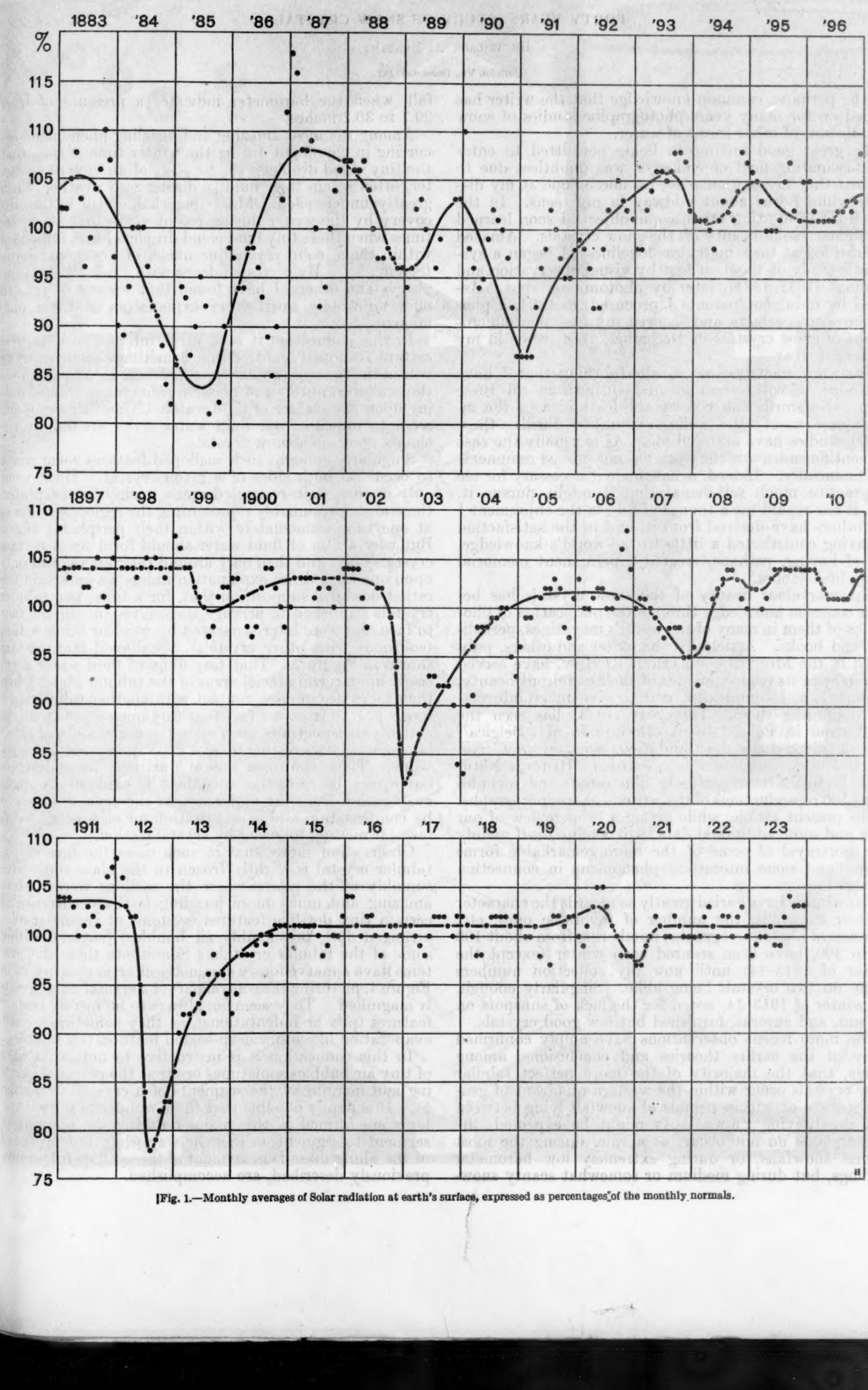


Fig. 1.—Monthly averages of Solar radiation at earth's surface, expressed as percentages of the monthly normals.

FORTY YEARS' STUDY OF SNOW CRYSTALS

By WILSON A. BENTLEY

[Jericho, Vt., December, 1923]

It is, perhaps, common knowledge that the writer has carried on for many years photographic studies of snow crystals and of other forms of water.

My great good fortune in being permitted to enter this fascinating field of endeavor was doubtless due to the fact that my mother placed a microscope at my disposal while I was about midway in my teens. In the search for interesting microscopic objects I soon learned of the marvelous beauty of the snow crystals. Amazed and thrilled at their matchless loveliness, I began a systematic study of them, at first by visual observation and drawings (1882–1884), later by photomicrographs. Assisted by indulgent parents I procured, in 1884, a photomicroscopic camera and secured my first photomicrographs of snow crystals in December, 1884, when in my nineteenth year.

The work soon became so all-absorbing that I have continued it with undiminished enthusiasm all these years. No words can convey the least idea of the intense enjoyment, the almost countless thrills, these winter studies have afforded me. As is usually the case in scientific endeavors the work has not proved remunerative financially. Indeed, it has made it necessary for me to practice much self-denial that I might pursue it. Yet, it has repaid me a thousand-fold in the enjoyment I and others have derived from it, and in the satisfaction of having contributed a little to the world's knowledge, and of having, perhaps, erected a permanent memorial to my life's labors.

The marvelous beauty of the snow crystals has become common knowledge through the publication of phographs of them in many of the world's magazines, periodicals, and books. Articles by the writer and others, published in the MONTHLY WEATHER REVIEW, have served to convey to its readers an idea of their wondrous beauty, symmetry, and complexity, and to give much information regarding them. This year (1923) has seen the publication in Poland by A. Dobrowski of "Belgica" fame, a splendid and most ambitious work on snow crystals and other forms of water, entitled "Historja Naturalna Lodu." It is profusely illustrated, and includes about 100 reproductions of the writer's photomicrographs.

The present article, while giving a brief review of our work and some additional data, will confine itself mainly to a portrayal of some of the more remarkable forms secured and some interesting phenomena in connection therewith.

The winters have varied greatly as regards the character of their snowfalls, the number of favorable ones, etc. New sets of photomicrographs, numbering from about 100 up to 300, have been secured each winter (except the winter of 1913–14) until now my collection numbers 4,200, no two crystals being alike. Singularly enough, the winter of 1913–14, noted for the lack of sunspots on the sun, and auroras, furnished but few good crystals.

The more recent observations have amply confirmed many of the earlier theories and conclusions, among others, that the majority of the more perfect tabular snow crystals occur within the western quadrant of general storms, or within regions of snowfall lying between two closely lying "lows." As might be expected, the best crystals do not occur, as a rule, during the most intense snowfalls, or during extremely low barometer readings, but during medium or somewhat scanty snowfall, when the barometer indicates a pressure of from 29.7 to 30.2 inches.

Among the most amazing and puzzling phenomena occurring in cloudland during the winter time is this, that the tiny cloud droplets, $\frac{1}{500}$ to $\frac{1}{3,000}$ of an inch in diameter, often retain their fluidity during zero weather, when greatly undercooled. More remarkable still is the discovery by the writer during recent years that there are times when these tiny fluid cloud droplets have, imbedded within them, solid crystalline nuclei of hexagonal form. (See fig. 1.). By correspondence with Prof. W. J. Humphreys and others, I have found that science as yet can offer no wholly satisfactory explanation of these phenomena.

In this connection it is of great interest to note that certain scalloped features that sometimes occur upon or within the faces of tabular snow crystals, greatly resemble the scalloped outlines of massive ice crystals when forming upon the surface of fluid water. They (the scallops) seem to indicate that fluid water once existed in the clouds upon such snow crystals.

Singularly enough, such scalloped features seem never to occur on both sides of a given crystal. They occur only upon certain restricted areas, encircling the plates, these areas presumably representing the region which was at one time immediately within their peripheral edges. But why a film of fluid water should form upon certain crystals only, and then only around their edges, and only upon one face, defies explanation unless we entertain the rather doubtful supposition that, for a time, two tabular crystals happened to arrange themselves in contact face to face and were later separated by wind or other action (collisions with other crystals). Scalloped features are shown in Figure 2. That tiny films of fluid water form easily upon certain facial areas of the tabular plates when their faces are in close contact with another tabular face seems proved from the fact that tiny microscopic scallops actually do sometimes form upon the under sides of tabular snow crystals resting upon a glass slide under a microscope. Those shown in Figure 3 actually formed before our eyes. In cases like this there is evidently a slight evaporation from the under side of the crystal, followed by condensation and crystallization, or else a slight surface (?) melting followed by crystallization.

Observation shows that in such cases the face of the tabular crystal is slightly frozen to the glass slide, presumably at the places where the scallops were. More amazing and much more puzzling is the occurrence of certain tiny dot-like features (systems of geometrically-arranged dots, presumably air bubbles) featured within some of the tabular crystals. Sometimes these dot systems have a marvellously symmetrical arrangement, as in Figure 4, picturing the central part of a crystal only, greatly magnified. They seem not always to be merely surface features (pits or indentations), as they sometimes resist evaporation like other deep-seated features (air bubbles).

In this connection it is instructive to note that lines of tiny air bubbles sometimes occur at the places of meeting and merging of the segments of a crystal. (See fig. 5). It is barely possible that these wonderful dotted systems are formed in this manner during the merging of segment to segment, or in some way while the processes of the filling in and encasement of the scalloped features, previously described, are accomplished.

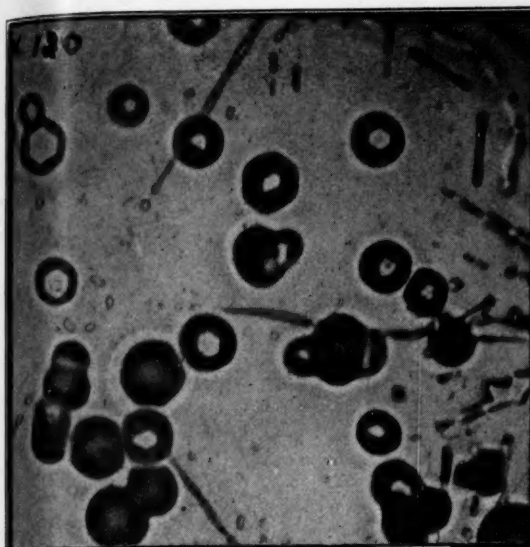


Fig. 1

Fig. 2

Fig. 3

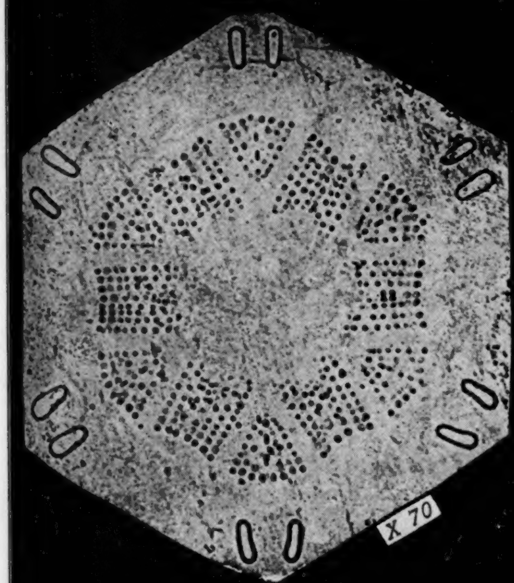


Fig. 4

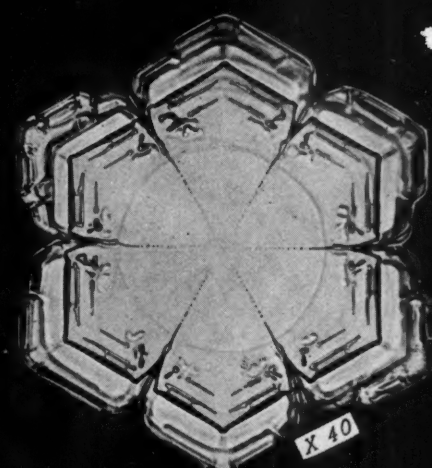


Fig. 5

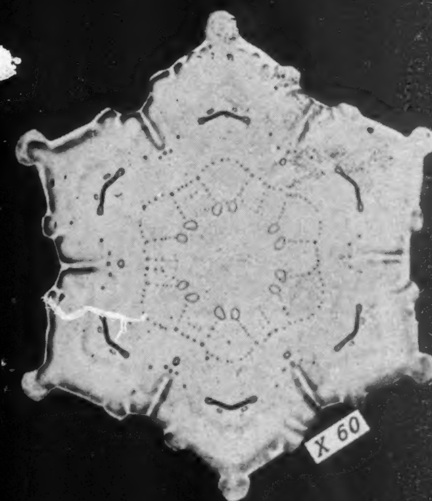


Fig. 6

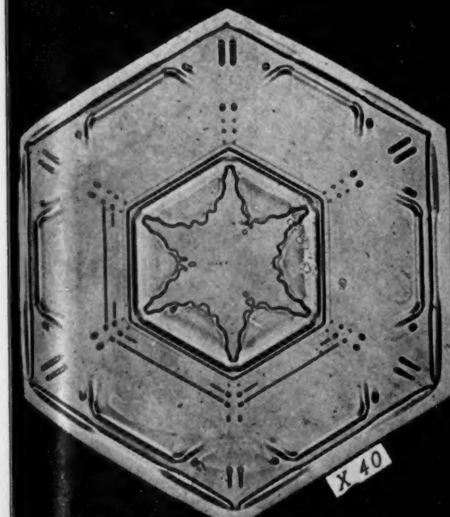


Fig. 7

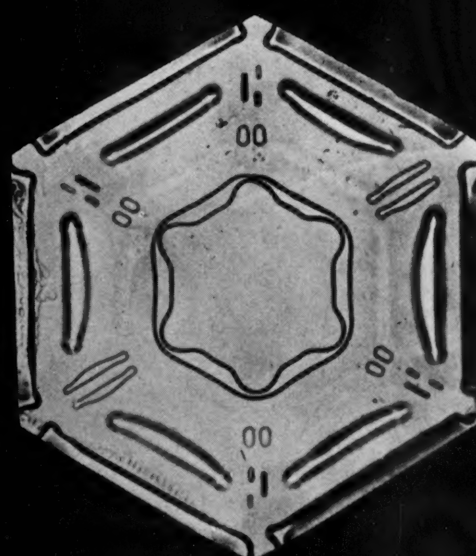


Fig. 8

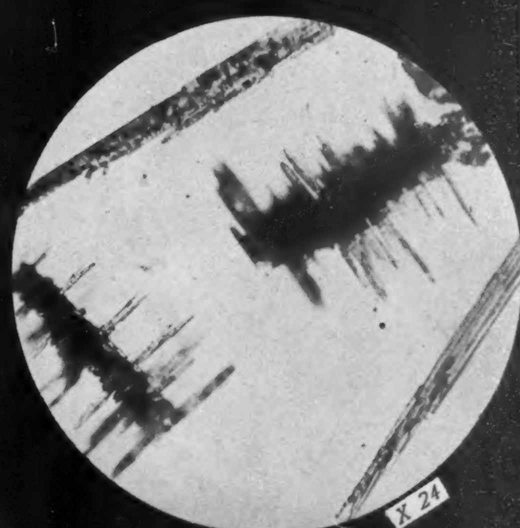


Fig. 9

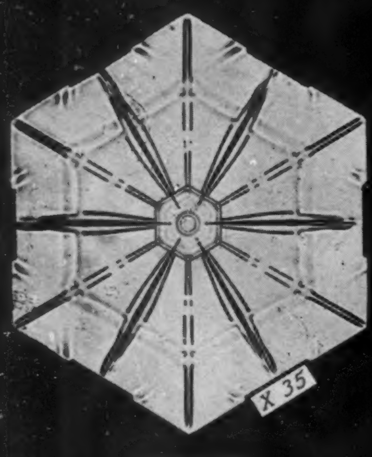


Fig. 10

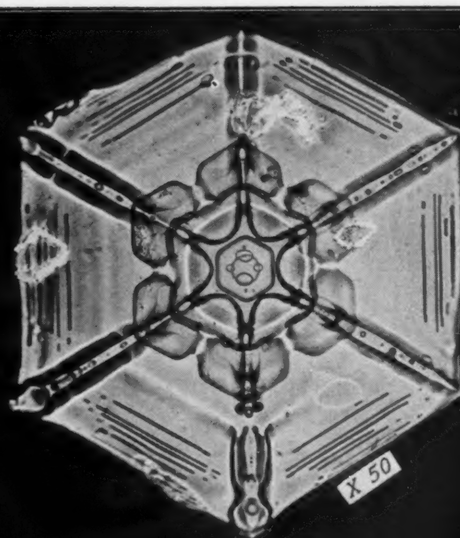


Fig. 11

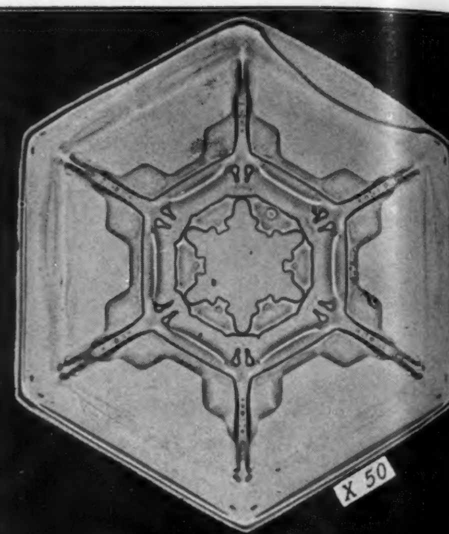


Fig. 12

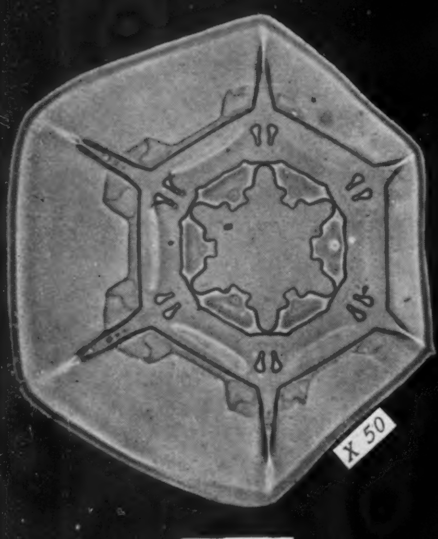


Fig. 13

Fig. 14

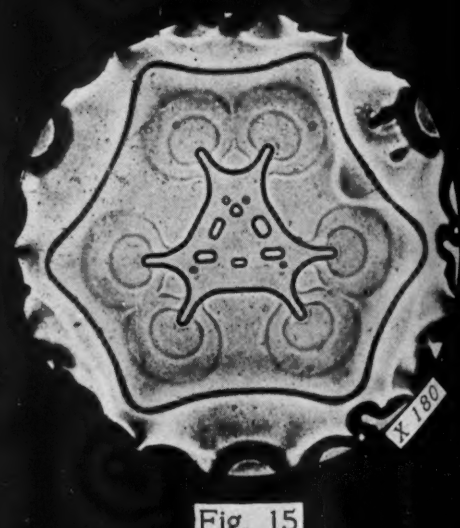


Fig. 15

Fig. 16

Fig. 17

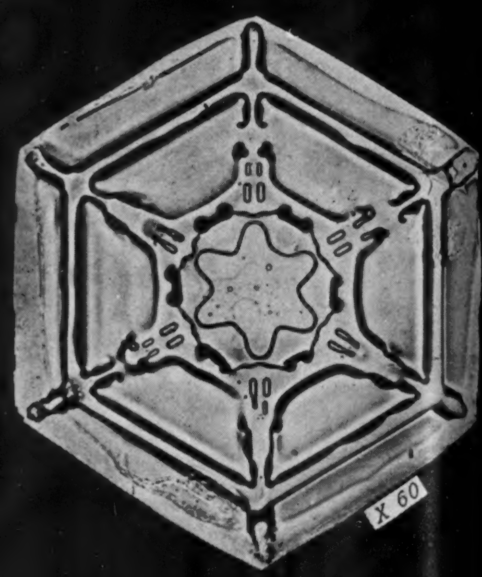


Fig. 18

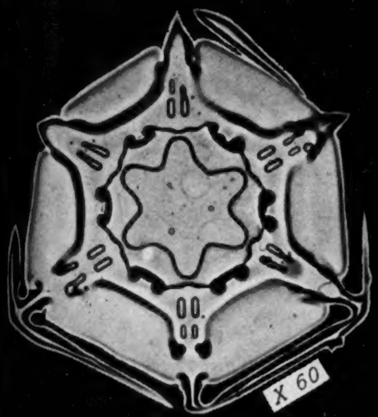


Fig. 19

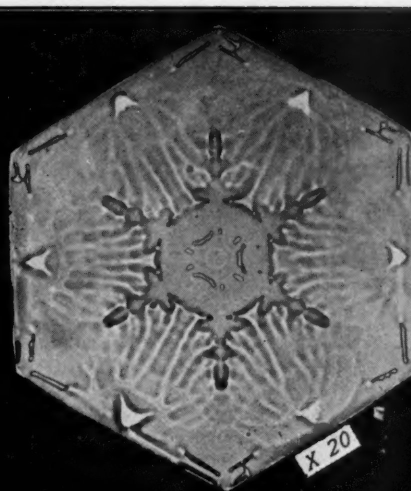


Fig. 20

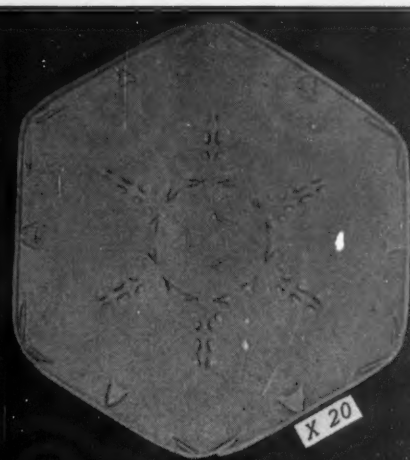


Fig. 21

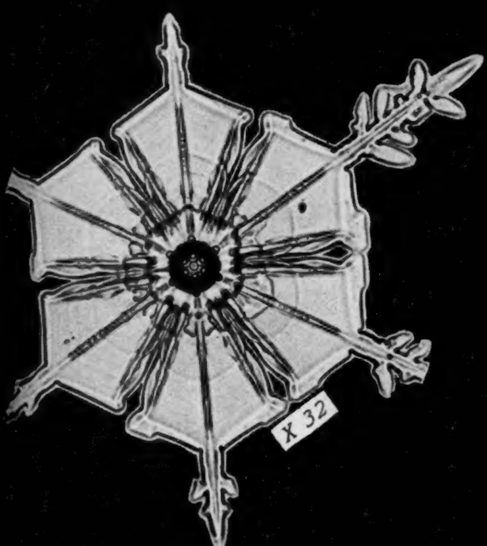


Fig. 22

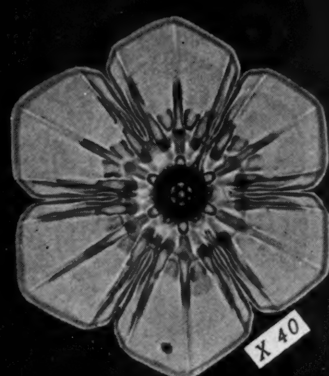


Fig. 23

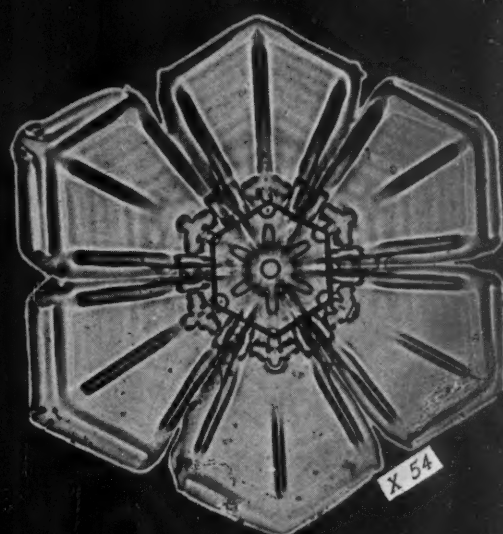


Fig. 24

Fig. 25

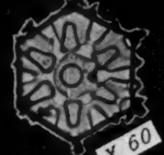


Fig. 26

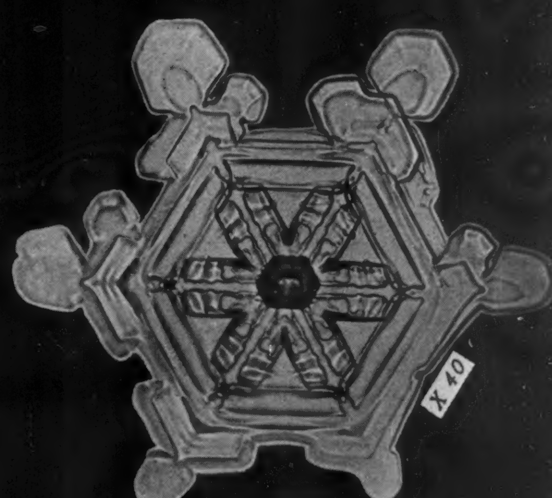
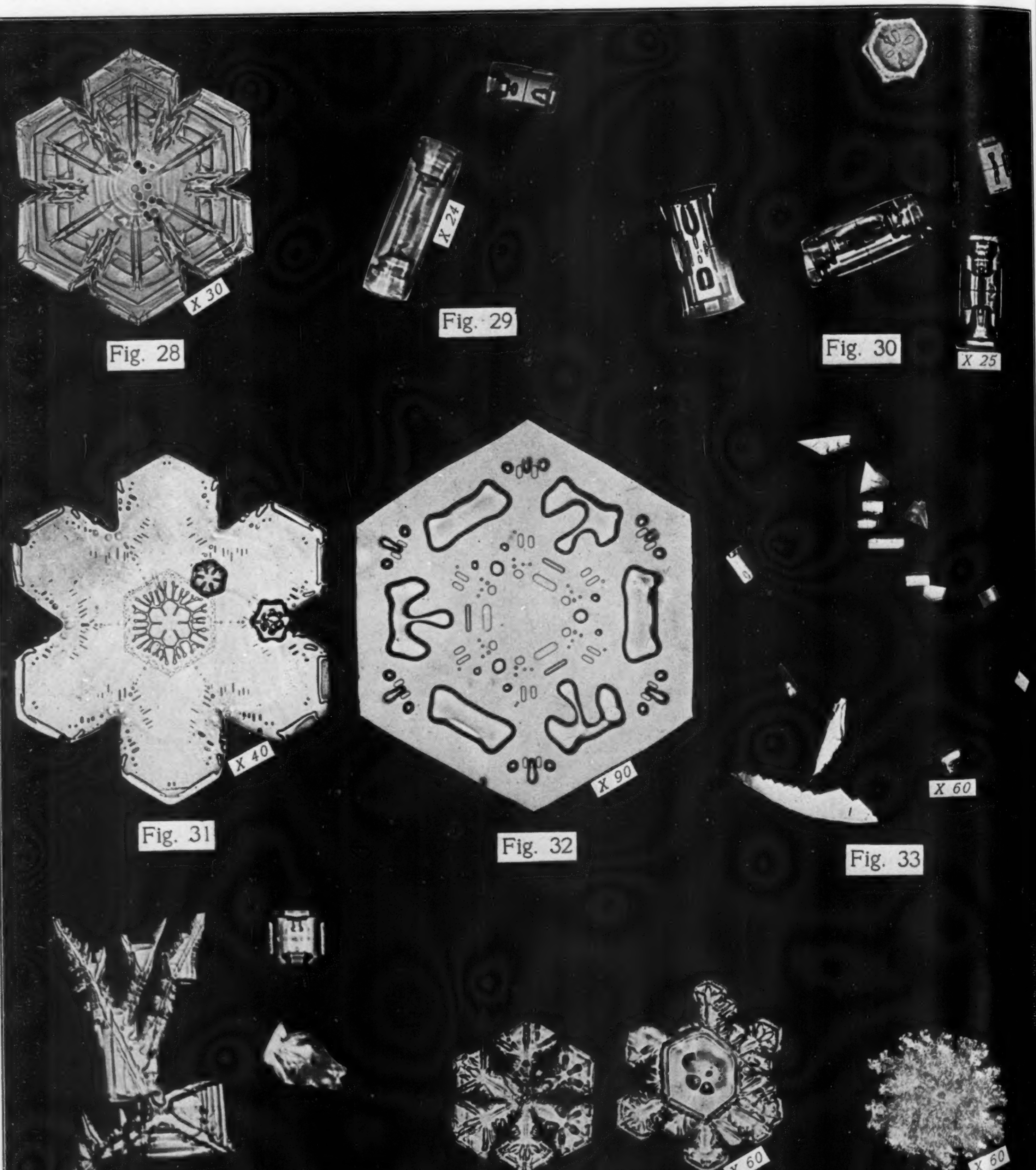


Fig. 27


X 30
Fig. 28
X 24
Fig. 29
Fig. 30
X 25
X 40
Fig. 31
X 90
Fig. 32
X 60
Fig. 33
X 60
Fig. 34
X 60
Fig. 35
X 60
Fig. 36

In Figure 6 we see the skeletonized outline of a similar system of dots. Figure 7 possess features of especial interest. It will be noted that certain slender rod-like features, presumably air tubes, encircle the nucleus just half way around, and no further.

I have many other specimens exhibiting this interesting crystallographic habit. Some specimens show a marvellously perfect balancing of opposite parts, similar parts similarly modified. Figure 8 is a most interesting case in point.

Figure 9, in part a profile view of plate forms, is of interest because it shows the manner in which the needle-like additions, presumably acquired within the lower clouds, attach themselves in positions normal to its faces.

The modifications the crystals undergo as a result of progressive evaporation (evaporative erosion) has received my earnest attention during recent years. My series of photo-micrographs, picturing such phenomena is as yet inadequate, but will be augumented as opportunities permit. Evaporative erosion may be divided into two categories, facial, occurring upon their faces, and peripheral, occurring around their edges. Facial erosion tends to make tabular plates thinner, and to reduce the size and relief of any raised portion thereon. It also tends to deepen and enlarge any pits or indentations or sunken features extending beneath their faces.

Peripheral erosion progressively tears the crystals down around their edges, making the stars and plates progressively smaller, and rounding off the sharper angles and projections. Peripheral erosion tends to proceed fastest and to make indentations (notches) at all places where the stars or plates are thinnest. Conversely, it tends to proceed most slowly at all places having more than usual thickness or greatest refractability. Observers differ as to the character of many of the internal features, the lines, dots, shadings, etc., within them, and evaporative erosion helps to throw light upon the matter.

Some features are universally conceded to be minute inclusions of air (air tubes); others, to be the result of abrupt changes in thickness, or partial opacity. The origin and character of others, as for example the dark axial rays (usually double dark lines) that often radiate outward toward the corners of the hexagons, and some other features, are still somewhat in doubt.

Some observers assert the dark axial rays are hollow air tubes, hence lines of weakness. The writer has always been skeptical regarding this conception of them. He believes that if air is included it is in infinitesimal quantities, and that it is only such as is included alongside the outer sides of each of the long dark axial rays instead of centrally between them.

The behavior of these various features while undergoing evaporation is instructive.

Before considering this it may be well to consider the aspect of real air tubes in massive ice and show crystals. When these are viewed by transmitted light they usually present the appearance of two dark parallel lines. The snow crystal, Figure 10, contains typical examples of such air tubes. Returning to our consideration of the dark axial rays, a close study of them reveals that tiny air bubbles are often strung along their extent. Assuming these tiny air bubbles to be deep-seated, which seems likely from their persistence during evaporative erosion it is obvious that air tubes can not exist within air tubes. (See fig. 11.) This behavior while undergoing erosion seems also not favorable to the hollow-tube theory of them. For they are often so broad that, assuming them to be air tubes, they are relatively large compared to the tabular thickness of the plates (see again fig. 11), and should be lines of weakness and maximum erosion, unless we assume a marked thickening of the plates at their locality, i. e., raised icy ridges projecting above the normal tabular face or faces.

It is frequently the case as evaporation progresses that the outward ends of the axial rays do not evaporate as fast as the surrounding solid parts, and hence project slightly beyond them as though these ends were unusually resistant to erosion. Such was the case with the flake in Figure 11, and also with many other specimens. Evaporation, moreover, sometimes practically destroys the axial rays by means of facial erosion before peripheral erosion approaches the destroyed parts, which seems to indicate they are extremely raised features rather than internal ones. True deep-seated air tubes persist the longest of any of the features of snow crystals which are undergoing evaporation.

Figure 12 shows how the axial rays are in process of destruction by facial erosion before the near approach of peripheral erosion, also how it operates to lessen the breadth of such axial rays in just the manner it should, assuming them to be slightly raised ridges upon the tabular face.

In a previous article the writer showed how a slight variation in thickness of one side of a plate as compared with the opposite side caused evaporative deformation, and was one of the causes operating to destroy perfect natural symmetry. It frequently falsifies the image even before the skilled photographer can photograph it. A fracture operates in the same manner. In the case of the flake in Figure 12 the writer broke off a little from one edge of the plate while picking it up with the wooden splint used for this purpose. The crystal, as will be noted, was marvellously perfect and symmetrical. After a little, another picture of it was made (fig. 13). As will be noted, evaporation progressed with undue haste at and around the injured part, thus destroying the symmetry of the crystal and falsifying its image. This last plate is also instructive, as before noted, because the crystal had axial rays, and we see here again how facial evaporation reduced the breadth and distinctness of the axial rays, before the near approach of peripheral evaporation. As previously pointed out, while facial evaporation tends to reduce the size and relief of raised facial features, it would tend to enlarge and deepen sunken features, pits, bubbles, etc.

This may possibly explain the increase in the size and distinctness of the round circular figures shown just outside of the points of the nuclear star in Figures 14 and 15. It will be noted that the first exposure reveals but one circle at each star point, those being much smaller than the circles brought into view by the second exposure. The increase in the size and distinctness of some of the nuclear stars seen at the centers of certain snow crystals as evaporation proceeds is puzzling. (See Figs. 16 and 17.) May it be due to internal melting? Or must we conclude that such nuclear stars are also sometimes thinner than the surrounding parts, thus forming differences in star shapes? Figures 18 and 19 are of great interest in once again showing how the axial rays, and dark, encircling lines as well, are unusually resistant to evaporation.

Singularly enough, certain broad shadowy features sometimes occurring in crystals similar to those in Figure 20, quickly disappear through evaporation. (See Fig. 21.) The evaporative modifications which the flake in Figures 22 and 23 underwent are of much interest, as are the three evaporation stages shown in Figures 24, 25, and 26.

It is well known that tabular snow crystals, and especially branchy ones, rotate face downward while falling. As a result, growth material is supplied in undue proportions to one side only of each of the rays, producing abnormal growth thereon. A similar result is produced when one edge of a crystal is thicker than the opposite edge, causing it to fall steadily downward. Figure 27 is an instructive example of this kind.

The problem as to the nature of the nuclei around which snow crystals form is of much interest. If such nuclei are, as some assume, dust particles, they must be exceedingly small, invisible to ordinary microscopic vision, as none are found in my photomicrographs. That many of the crystals seize upon and crystallize around frozen cloud droplets seems very probable, as the nuclei of at least one half the crystals are tiny circular figures, looking much like an encased cloud droplet. Further support is given this theory by the fact that they correspond in size, also, with the cloud droplets.

Figure 28 pictures one of these circular nuclei, with some attached cloud droplets.

The columnar snow crystals, singularly enough, show no evidence of having crystallized around cloud droplets, as they do not possess circular nuclei. Some of them, like some plate forms, have perfectly limpid formless nuclei. But more often they possess one characteristic nuclear or central feature. This consists of a faint line across the column at their centers, normal to their greater diameter, seemingly bisecting the column in the manner shown in Figures 29 and 30. Growth from the ends downward and meeting at the center of the column might produce such an appearance, and offers a possible explanation. These specimens are interesting, moreover, because they show the so-called end cavities, which do not always meet at the center of the columns. A third flake of this series [not reproduced] has collections of granular cloud-droplet material upon one edge [side?—Ed.] only, proving that such columns descend in accordance with theory, i. e., in horizontal position and without rotating.

All keen and long-time students of the snow must have been often thrilled at the rare beauty and perfection of many of the tiny centerpieces possessed by numbers of the tabular crystals. Often otherwise imperfect specimens possess amazingly perfect nuclear parts. Many of these wonderful imitation gem-like centerpieces are almost unbelievably beautiful specimens of geometric art worthy of the skill of a master artist. Frequently the details pictured therein are too minute to be clearly shown with the ordinary magnification, or when the whole crystal is shown.

The writer has photographed during recent years many highly magnified centerpieces, with most interesting and most beautiful results. Such photographs, while not showing the crystals in the final or mature stages of growth, are yet true to nature, for they do picture them as they once were while yet in an immature, uncompleted state, in the clouds. And in a way, crystals are always in an immature state. We really never see a mature crystal, for, unlike vegetable and animal organizations, they will continue to grow indefinitely just as long as material is supplied them. Sometimes such immature forms become attached to "mature" crystals, thus preventing further growth, and are brought down unmodified to earth, as shown in Figure 31.

A study of these snow-crystal centerpieces shows that, in general, they are of the solid or quasi solid plate form. Space forbids the picturing of more than two of these, enlarged. One has been shown in Figure 4, the other is pictured in Figure 32, which is a marvel of quasi trigonal symmetry.

It has been a mooted question among scientists whether or not crystals forming under identical conditions would be identical in form. In the case of the snow crystals, for example, would all those originating in the given portion of a cloud be alike? Through a fortunate accident, the bursting of a water pipe, thereby flooding the floor of a cold room, one very cold night (25° F. below zero), the writer had the opportunity of observing water vapor crystallization under practically ideal, or nearly laboratory, conditions. Of course the conditions of humidity, air density, etc., were uniform within this room.[1] Upon entering the room in the morning, wisps of fog rising from the floor, and tiny crystals of hoar frost glittered from the wall and upon all objects, including my glass microscope slides. I at once realized the importance of the phenomenon and of securing photomicrographs of the crystals. Finding those on my microscope slides to be fairly typical of all in the room, I hastily made as large a series as possible. Although the heat of my body speedily arrested further growth of the crystals near me and soon caused evaporation to round off the sharp corners of the crystals upon my glass slides, by rushing in occasionally and making an exposure and then withdrawing for a while, I succeeded in my purpose. The tiny frost crystals, if such they may be called, attained a degree of perfection of form in this room such as I never saw elsewhere. The crystals, while mostly of the columnar and solid tabular forms, were not all of that character nor all alike. Some few assumed branching or quasi branching forms. Singularly enough, some of the plates grew in a quasi trigonal manner. Others developed in oblong plate form. It is probable that the branching forms, especially those with curving habits of growth, may have been a later phase of crystallization, and that they formed only after the air of the room became, in local regions, supersaturated with moisture. The curving, branchy forms are doubtless but quasi crystalline like similar frost crystallizations on windows. It is probable that groups of water molecules, rather than single ones, groups so large that as the molecules unite they come only partly under crystallographic law, unite to form such curving crystals. These appear to be cases of colloid crystallization.

Singularly enough, some of the tabular forms possessed tiny circular nuclei seemingly identical with those possessed by many of the snow crystals. Broad dark axial rays were present in some of the plate forms. It is interesting to note that many of the columnar forms had end cavities resembling those in similar snow crystals. Photomicrographs of many of these wonderful frost crystals are shown in Figures 33–36.

It would seem, from my observations in this case, that crystals forming under identical conditions will not be all alike. It seems evident that hexagonal, trigonal and oblong plate forms, six-petaled forms, and columnar forms, etc., will form side by side under identical conditions.

In concluding this brief sketch of snow crystal studies, the writer wishes once again to express his ever-growing amazement at the seemingly infinite variety and thrilling beauty of the tiny snow crystal gems. Many of my recent finds are, if possible, more beautiful than the earlier ones. New and beautiful designs seem to be as numerous now as when I began the work 40 years ago. While many of them are very similar one to another, I have, as yet, found no exact duplicates.

In this inexhaustible storehouse of crystal treasures, what a delight is in store for all future lovers of snowflakes and of the beautiful in nature.

[1] It may be questioned whether, since the floor was wet, diffusion of water vapor from this source would not maintain a somewhat higher humidity near the floor.—Ed.

NOTE ON CERTAIN CLOUD FORMS OBSERVED AT TUCSON, ARIZ., AUGUST 18, 1924

A. E. DOUGLASS

[University of Arizona]

This note describes a certain form of cloud which has been seen a number of times during this unusually dry summer. At first glance this form resembles cirro-stratus, showing up to 5° altitude, long, nearly horizontal lines, occasionally inclined as much as 10° to the horizon. At higher elevations it looks like an etching in white against the otherwise clear blue sky, showing here and there groups of parallel lines or long sinuous curves. On June 3, 1924, near sunset, the crosshatching covered the western sky up to 30° altitude. The lines were a degree or so in width and 10° to 30° long and 2° or 3° apart. An attempt was made to photograph them without success.

On July 11 a similar and more pronounced display was seen near sunset from a moving train some 14 to 20 miles west of Needles, Calif. Again they had the crosshatching effect, covering the western sky up to 40° or 50° altitude. An attempt to photograph them showed only the nearly horizontal strata in the lower 5°. These seemed to me clearly different from cirro-stratus cloud. Their color was different, somewhat less white, and their outlines far softer and no fine detailed structure at all. In this observation some of the larger forms were watched for 15 minutes without important change. They faded away as night came on.

On August 18, at Tucson, a very brilliant display was first noted at 12.30 p. m. covering the western sky up to 30° or 40°. Photographs were taken but are not yet developed. At 1 p. m. the effect had spread over the whole sky, the bands overhead being 8° or 10° wide, perhaps 40° long, and very faint. In the east they were faint and smaller. A whitish haze surrounded the sun. The display lasted till about 5 o'clock. The western lines were horizontal in general effect yet usually in a wavy form like a rope that is thrown into stationary waves or a sine curve projected against the sky. There was a pronounced tendency for these long, soft, rippled lines to come in close pairs. By sighting on strong marks at 7° altitude a motion from near northwest was observed. Their height and real motion seemed worth trying for and were successfully obtained by rapid measures of altitude made at each end of a half-mile measured distance. A full measure consisted of altitudes at one end of the half mile and then the other end and then the first again. The distance was laid off on a straight road running east and west. It took about 10 minutes to get these three readings, and it was found advantageous to leave an observer at the first station, sighting carefully on the cloud form while the trip to and from the other station was being made. This was because continual change in the cloud lines was going on and pronounced forms lasted not much over 10 minutes. Seven measures were made of unequal value. Three good measures on well-defined points at low elevation gave 12,000, 14,000, and 20,000 feet altitude above the ground (elevation of Tucson is 2,400 feet above sea level).

Four poorer measures gave 7,300, 7,700, 10,000, and 28,000 feet. A general average of 15,000 feet or about 3 miles is probably some approximation to their height. Their motion was only a little over 4 miles per hour from north-northwest; this was for most of them a longitudinal motion.

The wind direction on that date was recorded as northwest and that evening a high current from west-northwest to northwest was seen in the big telescope. The attention of a number of townspeople was called to this phenomenon. Some said they had noted it on other occasions this summer. Quite a number of years ago, I observed a single band of this type of cloud moving longitudinally from west to east across the zenith. It was about 5° broad and probably 40° long. It obviously was not ordinary cloud.

Note added October 29, 1924.—Some of my photographs showed the special cloud forms on August 18, but the film had spoiled, and the pictures were not worth printing. I would like to say that since writing that note * * * I have observed the same type of cloud three or four times, and once under such conditions that I could identify them distinctly as a form of stratus cloud formed by the dissipation of cumulus clouds over a large, very dry valley bottom in which there was no irrigation or exposed water of any kind.

The clouds formed in the eastern side of this valley over the Tucson Mountains, 10 miles west of here. There was a slight easterly flow of air and the uprising clouds from that dry valley formed light cumulus clouds, and perhaps as the sun came to the west the upcurrent stopped, and the clouds dissipated along some layer where the motion of air was very slight.

MEETINGS OF THE METEOROLOGICAL SECTION OF THE INTERNATIONAL GEODETIC AND GEOPHYSICAL UNION, SECOND GENERAL ASSEMBLY, MADRID, SPAIN, OCTOBER 1–8, 1924[1]

By HERBERT H. KIMBALL

[U. S. Weather Bureau, Washington, D. C., December 16, 1924]

SYNOPSIS

The section held sessions for the discussion of its agenda on four half days, and an additional half day was devoted to joint sessions with the sections of Hydrology, Oceanography, and Terrestrial Magnetism and Atmospheric Electricity. The results of the discussions are embodied in a series of 27 resolutions, which may be classified as follows:

(*a*) Resolutions 4, 5, 14, and 15, in which questions were referred to some other organization for action.

(*b*) Resolutions 1, 6, 9, 11, 12, 13, 20, 21, 23, 24, 25, and 27, which express an opinion, or make a recommendation, but do not contemplate action on the part of the section.

(*c*) Resolutions 2, 3, 7, 8, 10, 16, 17, 18, 19, 22 and 26, which call for action on the part of the section.

Under (*a*) the 4 resolutions refer to cloud classification and the measurement of cloud heights; the centralization of meteorological observations made at sea; and trans-Atlantic steamer tracks.

Under (*b*) the 12 resolutions refer to the collection of publications of the Union in designated libraries; the determination of the variability of the hydrogen content of the atmosphere; spectral measurements of solar radiation at Izana, Canary Islands: the extension of radiotelegraphic transmission of meteorological observations; daily observations of temperature and pressure in the free air; an increase in the number of hydrological and meteorological stations in mountainous districts; the simplification of the Gregorian calendar; extension and improvement of the network of stations in the south Pacific; observations of air-borne parasites;

[1] Paper presented before the meeting of the American Meteorological Society, Washington, D. C., January 2, 1925.

and commendatory of the work inaugurated at Teneriffe and on the Jungfrau col.

Under (*c*) the 11 resolutions relate to administrative work of the bureau of the section; sampling the air at great heights; the equipment of additional stations with radiation apparatus; the measurement of the relative brightness of ground and cloud surfaces; illustrations of methods employed in forecasting the weather; cooperation in obtaining sounding balloon observations; atmospheric dust investigations; illustrations of the application of a simplified calendar to meteorological observations; and the compilation of weather charts of the Northern Hemisphere.

NOTES ON THE ASSEMBLY

It will be recalled that the first assembly of the International Geodetic and Geophysical Union was held in Rome, May 1-10, 1922, in connection with the International Astronomical Union. It was the intention to hold triennial meetings of these unions, but so much inconvenience arose from holding simultaneous discussions in different assemblies on subjects of interest to members of both unions that it was decided to separate the meetings of the two. Therefore, the Union of Geodesy and Geophysics fixed the date of its next meeting for 1924, and the Astronomical Union for 1925.

October is a beautiful month in Spain, and especially in Madrid. During the time of the assembly there was practically no rain, the skies were generally clear, and the air had a crispness that was invigorating. The marked temperature changes from day to night were trying to some of the delegates, and bronchial colds became rather prevalent.

The hospitality of the Spanish nation and people was both lavish and hearty, and aided in stimulating a spirit of cooperation among the delegates that contributed materially to the successful solution of questions that arose during the discussion of the agenda of the different sections, and of the union as a whole.

The printed list of delegates contains 132 names, exclusive of the Spanish delegates, representing 31 different countries. It is of interest to note the increase over the Rome meeting in both the number of delegates and in the countries they represented. In the Meteorological Section increased interest was manifest in the discussion of the articles of the agenda. The attempt was made to exclude from the discussions questions primarily relating to administrative matters, and to include only problems relating to the physics of the atmosphere.

All the meetings were held in the Palace of the Chamber of Deputies. There was a commodious assembly room for the plenary meetings of the union, numerous board and committee rooms for the meetings of the sections, a writing room, and a restaurant in which the service was free.

At the inaugural meeting of the union on the morning of October 1, His Majesty the King presided, assisted by representatives of the Spanish Government. An address of welcome to the delegates was made by the chairman of the Spanish committee, Señor Luis Cubillo, which was responded to by the president of the union, M. Ch. Lallemand. Members of the families of delegates attended this meeting. At 6.30 p. m. delegates and their families attended a reception and concert at the Hotel de Ville, where there were more speeches, and delightful sociability.

The morning of October 2 was devoted to a plenary meeting of the union, and in the afternoon the different sections held their first meetings. The meteorological section met with its president, Sir Napier Shaw, in the chair. R. G. K. Lempfert, Esq., of the British Meteorological Office, was appointed temporary assistant to the secretary, Prof. Filippo Eredia. With the exception of the enforced absence of the president at the session of October 4 on account of illness, these officers were present at every meeting of the section. This first meeting was given up to consideration of the report of the executive committee, a summary of which has already been given in the Monthly Weather Review for July, 1924, **52**: 352-354.

On October 3 the delegates and their families were taken by a special train provided by the Minister of Public Instruction to the city of Toledo for a visit to the Central Seismological Station and to the various public buildings of that ancient city. This again was a pleasant social affair as well as a scientific pilgrimage.

On the morning of October 4 the Meteorological Section commenced the consideration of its agenda. In the absence of the president, the writer of this paper was asked to preside.

In the afternoon delegates and their families were taken in automobiles to visit museums and other points of interest in Madrid. At 10 p. m. they were received in the Royal Palace by the King and his family.

Monday morning, October 6, the Section of Meteorology first held a joint session with the Section of Hydrology, presided over by B. H. Wade, Esq., of Egypt, president of the latter section, and then in succession joint sessions with the sections of Oceanography, and of Terrestrial Magnetism and Atmospheric Electricity, with Sir Napier Shaw presiding.

In the afternoon delegates and their families were taken in automobiles to visit the meteorological and the astronomical observatories, and the Geographical Institute. In the evening they were entertained at a concert in the Royal Theater.

At the morning session of the Meteorological Section on October 7, the consideration of the items of the agenda was completed, and in the afternoon the formal ratification of tentative action on the various items, including the allotment of funds for certain projects, was effected through the adoption of a series of resolutions, which in their final form, after translation from the French, read as follows:

Resolutions adopted by the section of meteorology at the Madrid meetings, October 1-8, 1924:

1. That the union should take steps to obtain from the research council a statement as to the libraries, in the different countries, in which the publications of the union should be assembled, as well as publications received in exchange for those presented to other organizations.
2. (Provides for a card index of names for the regular distribution of the Procés-verbaux.)
3. (Provides for the distribution of notices of prospective meetings.)
4. That the proposal of the national committee of the United States regarding cloud classification (*a*) for scientific study and (*b*) for use in daily weather reports be referred to the International Commission for the Study of Clouds.
5. That the proposal of the national committee of Italy regarding the measurement of the height of clouds be communicated to the International Commission for the Study of Clouds.
6. That the bureau of the section be requested to draw the attention of the Union of Chemistry to the desirability of using cryogenic apparatus for the determination of the amount of hydrogen in the atmosphere from time to time.
7. (*a*) That the national committee of the United States be requested to bring forward details of the proposals for obtaining samples of air from great altitudes.

(*b*) That the attention of the national committee of the United States be drawn to the similar work done by the late M. Teisserenc de Bort.

(*c*) That a sum not exceeding £50 may be appropriated to these observations at the discretion of the executive committee of the Section of Meteorology.

8. That a commission be appointed with a grant of £400 (subject to that sum being available when the final allocation of funds is made) the money to be devoted to the supply of:

(*a*) Instruments (especially self-recording pyrheliometers or pyrgeometers estimated to cost $250 (£55) to be used in (i) Northern Canada or Spitzbergen, (ii) New Zealand or Samoa, (iii) Brazil (Amazon Valley) or Belgian Congo, (iv) the South Orkneys, (Argentine Weather Service) provided that the respective authorities are willing to undertake to use them:

(*b*) Instruments at an estimated cost of £14 10s each according to Mr. Richardson's design, with such modification as may be thought desirable, to four countries which have airplanes at their disposal (France, Great Britain, Italy, United States), after testing the instrument under service conditions.

The following were nominated members of this commission: MM. Kimball (president), Ångström, Gorczyński, Simpson, Platania, Maurain.

9. The Meteorological Section of the International Union of Geodesy and Geophysics expresses the desire that the Meteorological Service of Spain may find opportunity and means to organize at the observatory of Izana in the Canary Islands permanent spectral measurements of the intensity of solar radiation.

10. The Union of Geodesy and Geophysics expresses the wish that the Central Meteorological Service of each country should illustrate by an example the methods on which its forecasts are based. The day selected should be the 25th of September, 1923 (forecasts for the 26th—Cloud Week). Each country should set out the forecasts for its own area but should relate them to the general situation prevailing over the continent to which that area belongs, in such a manner as to bring out the scientific principles on which the forecasts are based. The documents and attached charts should be sent to the secretary of the section for compilation with a view to publication.

It was stated that the French Bureau Central Météorologique was prepared to undertake the publication.

11. The Union of Geodesy and Geophysics expresses the desire that the exchange of observations by radio-telegraphy between North America and Europe should be developed as much as possible and in particular that the United States and France should consider the possibility of transmitting and broadcasting in Europe observations from the Pacific Ocean and from Japan.

12. The Union of Geodesy and Geophysics expresses the wish that the Central Meteorological Services should foster a network of stations for the daily observation of the temperature and pressure in the free air by means of airplanes.

13. The combined sections of Hydrology and Meteorology of the International Union of Geodesy and Geophysics express the wish that the *reseau* of meteorological and hydrological stations in the mountainous districts be increased.

14. The Section of Meteorology has heard the proposals of the Section of Oceanography with great interest and approves cordially the proposal to centralize the collection of observations for limited areas as far as possible. It directs its bureau to take steps to request the International Meteorological Committee to give this question favorable consideration.

15. Without expressing an opinion thereon the section instructs its bureau to take steps to bring the communication of MM. Eredia and Maranello to the notice of the International Hydrographic Association.

16. That the bureau of the section be requested to continue its endeavors to obtain observations with *ballons-sondes* and *ballons-pilotes* from the sea and from special regions on land and that the balance of the sum voted in 1922, viz: 25,000 francs capital, 21,200 francs for each of two years, in all 67,400 francs less the expenditure up to date 3,250 francs, 64,150 francs (£750) continue to be at the disposal of the bureau for this purpose as heretofore, for the provision of instruments including the sextant theodolite for use on board ship, provided that any sum granted towards the publication of the results of *ballons-sondes* be included in this grant.

17. That the sum of £500 be allocated to the president in his capacity as president of the International Commission for the Study of the Upper Air in aid of the publication of a year's results of observations of the upper air to be used in addition to any sums that may be contributed for that purpose by countries which do not adhere to the union.

18. That the days selected for the observations of dust in the year 1925 should include international days of the Commission for the Study of the Upper Air.

19. That a small commission be appointed to arrange and advise concerning further investigations [of atmospheric dust] including the relation between dust and visibility and also the potential gradient of atmospheric electricity. Messrs. Owens, Eridia, Angström, Kimball, Jaumotte, were nominated members of the commission.

20. The Section of Meteorology urges the early consideration of the simplification of the Gregorian Calendar by the "Advisory and Technical Committee on Communications and Transit" of the League of Nations and that appropriate steps be taken to bring about international consideration and if possible the adoption of its recommendations.

21. That the section approves and recommends as units of time for meteorological purposes:

(1) The mean solar day.

(2) A week of seven solar days.

(3) A year made up of 51 weeks of 7 days and 1 week of 8 days; but in leap year, 50 weeks of 7 days and 2 weeks of 8 days.

(4) The hour, $\frac{1}{24}$ of the mean solar day.

(5) The second, $\frac{1}{86,400}$ of the mean solar day.

22. That the section invites those who are specially interested in the question to circulate at some convenient time a calendar for the year 1925 showing exactly how they would desire meteorological observations to be dealt with.

23. In view of their great importance for the study of meteorology, the Meteorological Section of the Geophysical and Geodetic Union expresses the hope that steps may be taken by the governments concerned to improve and extend the organization of the network of stations in the south Pacific Ocean and to coordinate the results.

24. The section expresses the desire that the central meteorological services establish a system of observations on air-borne parasites and that these observations be published as widely as possible.

25. The meeting congratulates Señor Galbis on the arrangements that have been made for the study of the physics of the atmosphere at Teneriffe, and looks forward with pleasurable anticipation to the results which will be given to science by that observatory.

26. The section decides to make, as an example and on a precisely limited subject, a test of the services which would be rendered by the International Meteorological Bureau, the organization of which is now being studied by a commission of the International Meteorological Committee.

The problem to be solved, chosen from those which clearly involve international collaboration, is the following:

The compilation of an atlas of daily or bidaily charts covering the greatest possible part of the Northern Hemisphere for the third quarter of the year 1923.

M. La Cour, president of the North Atlantic Chart Commission, will have charge of the execution of the work. He will work under the instruction of a commission including members of the union belonging to the above commission of the international committee. A sum of £500 will be allotted for the work.

27. The section notes with satisfaction that Switzerland has established an observatory on the Jungfrau col, and expresses the hope that it may be actively employed in the international work of meteorology.

Finance.—The following financial statement showing the anticipated income of the section and the proposed allocation of the funds was submitted:

	Expenditure 1922-1924	Proposed expenditure for 1924-1927
	£ sterling	*£ sterling*
Printing and secretarial expenses of the bureau	9	
Capital recurring	70	[1] 105
Composition of the upper atmosphere		50
Exploration of the upper atmosphere, including contribution toward the cost of publication of an international volume of results	60	750
Dust	65	
Solar radiation		400
Daily synoptic charts of as much as possible of the Northern Hemisphere		500
	204	1,805

[1] £ sterling 35 per annum.

PROSPECTIVE INCOME

	£ sterling
Balance in hands of treasurer	368
Balance in hands of general secretary, 29,111 francs	485
Income for 1924	230
Income for 1925, 1926, 1927	697
	1,780

The minutes of the meetings of the section will be published later by the bureau of the section, and in many cases will clarify the meaning of the resolutions.

On the evening of October 7, delegates and their families were entertained by the Spanish committee at a banquet, followed by a concert.

NOTE.—The cost of an international publication of the results for the upper air for one year has been estimated by the Commission for the Study of the Upper Air at £2,000, exclusive of the cost of compilation and reduction.

On the morning of October 8 the final plenary meeting of the union was held for the consideration of questions of interest to the whole union as distinguished from those that pertained to the work of the individual sections only.

Before adjournment it was voted to accept the invitation of the delegates from Czechoslovakia to hold the next assembly of the union in Prague in 1927.

Probably the outstanding accomplishment of the section, the results of which will be awaited with great interest, is the provision in resolution 26 for testing the service that might be rendered by an International Meteorological Bureau. The work of compiling an atlas of weather maps of the Northern Hemisphere, with all possible completeness, for the third quarter of 1923, is a project worthy of international cooperation. However, the discussion as recorded in the minutes shows that grave doubts were entertained by some as to the propriety of "placing money at the disposal of an existing State service for carrying on work of an international character in conjunction with a commission."

Acknowledgment is made of the kindness of Secretary Eredia and Assistant Secretary Lempfert, in placing at the disposal of the author copies of the minutes of the meetings, including the text of the resolutions that were adopted.

AN APPROACH TO RUNOFF EXPECTANCY

S. L. MOYER, C. E.

[Montevideo, Minn., August, 1924]

The economics of the design of waterways for such purposes as drainage, spillways, bridge and culvert openings, etc., must fundamentally depend upon the frequency with which various run-off magnitudes may be expected.

Comparison of run-off data from different watersheds for any purpose, has very little meaning unless in some way account is taken of this factor of expectancy.

If a series of observations is arranged in the order of magnitude, and the frequency is defined as the interval of time between events of a given or exceeding magnitude, each observation being representative of a given unit of the total period covered equal to the unit in which frequency is measured, then the center of the series has a frequency value of 2 and the maximum observation has a frequency value equal to the total number of observations in the series.

Series frequencies.—From the above facts is deduced the method for determination of the various frequencies outlined as follows.

To determine the frequency for a given observation in a series, arrange and number the observations in the order of their magnitude, then the frequency

$$F=\frac{a}{b-N} \text{ in which}$$

N=the numerical designation of the observation,

$$a=T+2\,\frac{T-1}{T-2}-1 \text{ and } b=T+\frac{T-1}{T-2} \text{ in which again}$$

T=the total number of observations in the series, each observation representing an interval of time equal to the unit in which the frequency is expressed and F=frequency or interval of time, in the given unit, between events of a given or exceeding magnitude.

Total number observations in series (T)	$\left(T+2\frac{T-1}{T-2}-1\right)$ (a)	$\left(T+\frac{T-1}{T-2}\right)$ (b)	Total number observations in series (T)	$\left(T+2\frac{T-1}{T-2}-1\right)$ (a)	$\left(T+\frac{T-1}{T-2}\right)$ (b)
5	6.667	6.333	19	20.118	20.059
6	7.500	7.250	20	21.112	21.056
7	8.400	8.200	21	22.106	22.053
8	9.333	9.167	22	23.100	23.050
9	10.286	10.143	23	24.095	24.048
10	11.250	11.125	24	25.090	25.045
11	12.222	12.111	25	26.086	26.043
12	13.200	13.100	26	27.083	27.042
13	14.182	14.091	27	28.080	28.040
14	15.167	15.083	28	29.077	29.038
15	16.153	16.077	29	30.074	30.037
16	17.142	17.071	30	31.071	31.036
17	18.133	18.067	31	32.069	32.034
18	19.125	19.063	32	33.067	33.033

Total number observations in series (T)	$\left(T+2\frac{T-1}{T-2}-1\right)$ (a)	$\left(T+\frac{T-1}{T-2}\right)$ (b)	Total number observations in series (T)	$\left(T+2\frac{T-1}{T-2}-1\right)$ (a)	$\left(T+\frac{T-1}{T-2}\right)$ (b)
33	34.065	34.032	52	53.040	53.020
34	35.063	35.031	53	54.039	54.020
35	36.061	36.030	54	55.039	55.019
36	37.059	37.029	55	56.038	56.019
37	38.057	38.029	56	57.037	57.019
38	39.055	39.028	57	58.036	58.018
39	40.054	40.027	58	59.036	59.018
40	41.053	41.026	59	60.035	60.018
41	42.051	42.026	60	61.035	61.017
42	43.050	43.025	61	62.034	62.017
43	44.049	44.024	62	63.033	63.017
44	45.048	44.024	63	64.033	64.016
45	46.047	46.023	64	65.032	65.016
46	47.045	47.023	65	66.032	66.016
47	48.044	48.022	66	67.031	67.016
48	49.044	49.022	67	68.031	68.015
49	50.043	50.021	68	69.030	69.015
50	51.042	51.021	69	70.030	70.015
51	52.041	52.020	70	71.029	71.015

After finding the frequency for each observation, the series may be plotted against various functions of the frequency until some function is discovered which causes the observations so plotted to approximate a straight line, and the function so determined is determinate of the relation of magnitude to frequency for the series under consideration.

Annual peak flows so plotted for a number of streams suggest that, for the more frequent events at least, peak flows on any stream tend to approximate a straight line when plotted against

$$\left(\frac{1}{2F}+\frac{4\cdot 5}{F+8}\right) \text{ in which } F=\text{frequency.}$$

A chart for ready determination of the various values produced by this expression is given in Figure 1.

Designating this expression as d, these same plottings seem to indicate that peak flows for any stream follow a law expressed by a formula of the form of

$$Q=(c-d)e$$

$$\text{in which } d=\left(\frac{1}{2F}+\frac{4\cdot 5}{F+8}\right),$$

Q=magnitude of flow,

F=frequency or interval in years between peak flows of a given or exceeding magnitude,

ce=limit which magnitude approaches.

By plotting the discharges from various watersheds against d, it is possible to compare any number of records on a basis which gives rational weight to the length of the record and by computing and charting d for various values of F it is possible to construct a frequency scale conforming to this straight line relation, thus affording

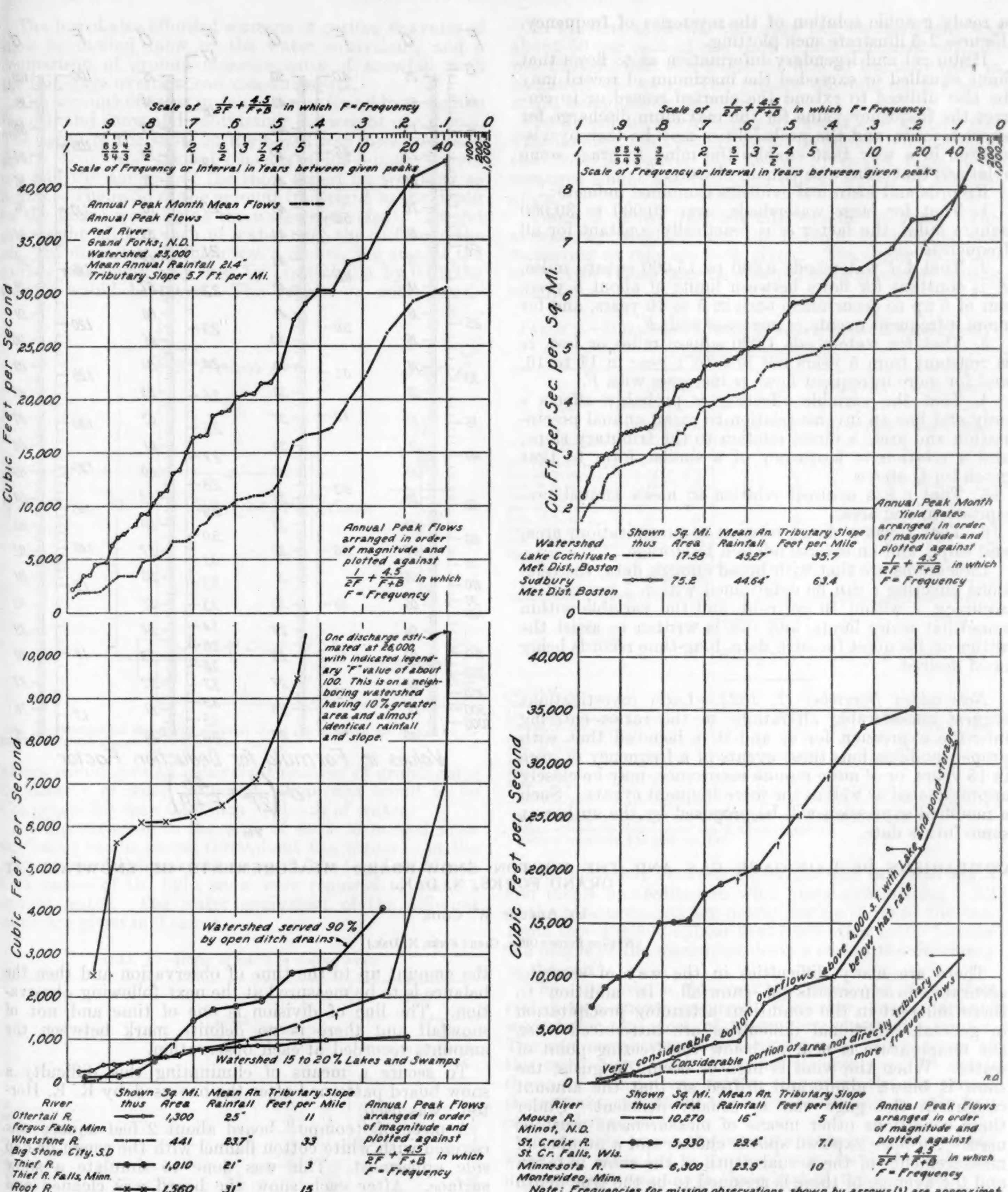


FIGURE 2 (upper left) FIGURE 4 (lower left) FIGURE 3 (upper right) FIGURE 5 (lower right)

a ready graphic solution of the mysteries of frequency. Figures 2–5 illustrate such plotting.

Historical and legendary information as to flows that have equalled or exceeded the maximum of record may be also utilized to extend the charted record or to correct the frequency value for the maximum discharge for short records, and the probabilities may be thereby visualized in a way that enables the mind to grasp some relations that otherwise remain obscure.

Records and historical evidence examined indicate:

1. That for large watersheds, over 20,000 to 30,000 square miles, the factor *ce* is practically constant for all frequencies.
2. That for watersheds 5,000 to 15,000 square miles, *ce* is constant for flows between limits of about 5 years out of 6 up to occurrances once in 5 to 10 years, and for more infrequent events *ce* increases with *F*.
3. That for watersheds 1,000 square miles or less, *ce* is constant from 5 years out of 6 to 1 year in 14 to 16, and for more infrequent flows *ce* increases with *F*.
4. That the variable affecting *ce* probably affects *e* only and has an inverse relation to mean annual precipitation and area, a direct relation to the tributary slope, and a relation to frequency of a similar form to that given for *Q* above.
5. That *c* has a direct relation to mean annual precipitation, and area.
6. That *e* has a direct relation to precipitation, area, and slope, and an inverse relation to storage.

Indications are that with broad enough data, the relations affecting *c* can be determined within 5 per cent of accuracy, *e* within 10 per cent, and the variable within somewhat wider limits, and this is written to assist the author in his quest for such data, long-time records being most desired.

Note added November 17, 1924.—Later investigations suggest considerable alterations in the ratios entering into the expression for *d*, and it is believed that with proper modifications those events of a frequency of once in 15 years, or of more remote occurrence, may be closely approximated as well as the more frequent events. Such a modified expression will be proposed by the author at some future date.

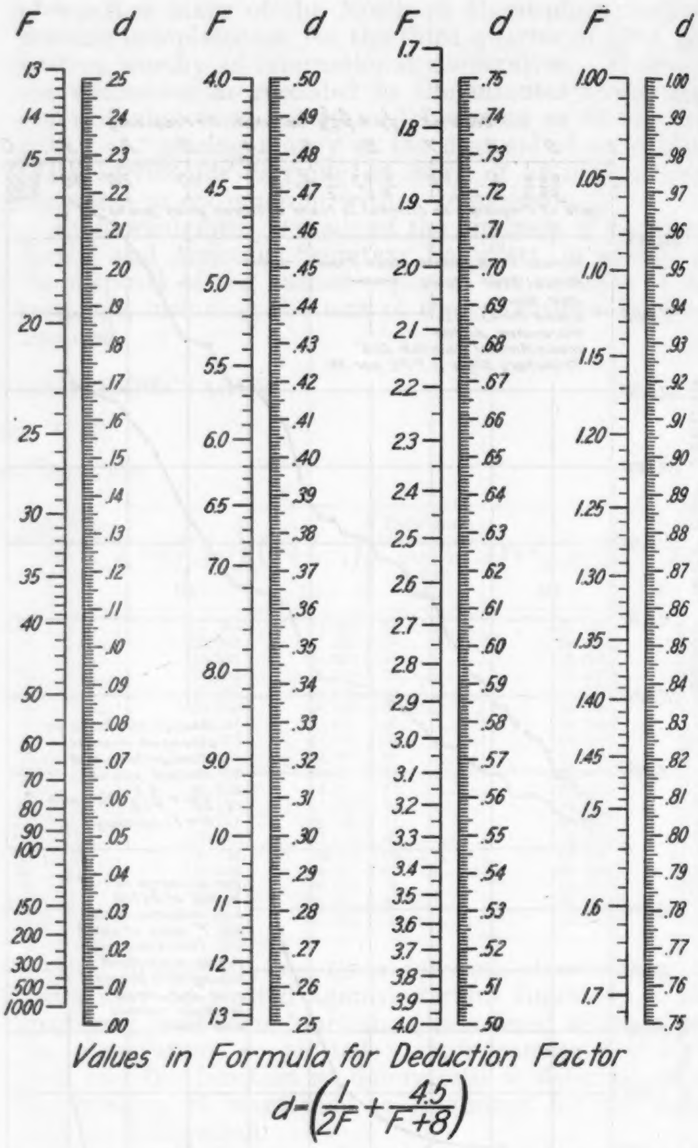


FIG. 1

COMPARISON OF RAIN-GAGE CAN AND THE HORTON SNOW-BOARD MEASUREMENTS OF SNOWFALL AT GRAND FORKS, N. DAK.

By ALBERT W. COOK

[Weather Bureau Office, Grand Forks, N. Dak.]

There are many difficulties in the way of securing accurate measurements of snowfall. In addition to those inherent in the conditions attending precipitation in general, additional difficulties are introduced when the temperature is near or below the freezing point of water. When the wind is high or occurs in gusts, the snow is blown about and drifted so that the amount caught in the gage can is usually deficient. Under these conditions other means of measurement must be used. An open exposed spot is chosen and a number of measurements of the actual depth of the snow is taken and the average of these is assumed to be the true depth of the snow. This method of measuring gives a fairly close measurement of the depth if the ground was clear when the snow fell. When new snow has fallen on old snow, it is difficult to determine the depth of the new snow. This is especially true when snow is falling at the time of observation. Measurement must be made of the amount up to the time of observation and then the balance is to be measured at the next following observation. The line of division is one of time and not of snowfall and there is no definite mark between the amounts recorded at each observation.

To secure a means of eliminating this difficulty a snow board patterned after the one used by R. E. Horton [1] was used.

A piece of "compo" board about 2 feet square was covered with white cotton flannel with the rough or nap side uppermost. This was done to simulate a snow surface. After each snow the board was cleaned and placed on the newly fallen snow.

The actual depth of the snow could be secured by measuring the depth of the snow on the board. There would be no possibility of including the old snow.

[1] MO. WEATHER REV., 1920; 48: 88-89.

The board also afforded a means of getting the ratio of snow to melted snow or the water equivalent, and a comparison of ground measurements of snowfall with the rain-gage overflow can measurements.

The amount of snow in the can was found by weighing the can and snow and subtracting the weight of the can. The depth of the snow on the board was measured and then a "cut" was taken by means of the 8-inch receiver top and the amount of the snow found by weighing as before. The ratio of the amount by weight to the depth on the board would give the water equivalent. To get the weight of 0.01 inch of water over the surface of the can, the diameter of which was 8 inches, the area of the surface was found and then by multiplying by 0.01 the volume would be given. The volume in cubic centimeters would give an equivalent number of grams since the density of water is unity. This was found to be 8.23 grams for each 0.01 inch of depth of water.

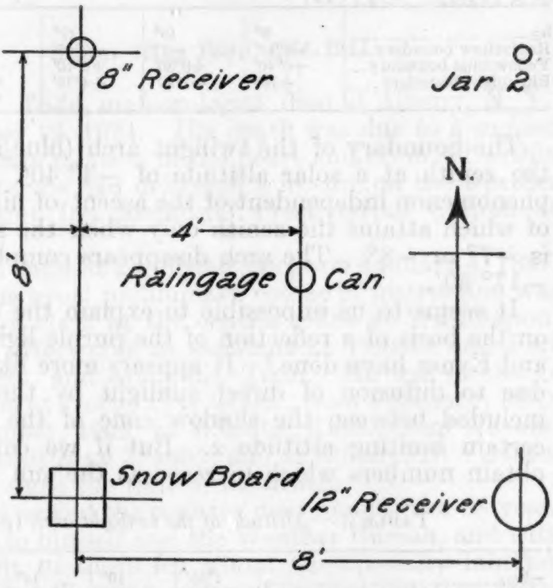


FIG. 1.—Arrangement of jars and receivers about the rain-gage can in test for influence of height of gage on catch of snow.

A wide variation in the ratio of snow to melted snow was found in the snows throughout the winter. In the heavy snow of February 19, it was 7.5 to 1 and on March 3, 42 inches of the light snow were required to make 1 inch of water. The water equivalent of the different snows are given in Table 1.

TABLE 1.—*Ratio of snow to melted snow*

Date	Depth of "cut"	Melted	Ratio	Wind: Direction	Wind: Velocity (miles per hour)
	Inches	*Inch*			
Jan. 11	1.5	0.05	30	N	4
Jan. 13	.12	.01	12	NW	6
Jan. 23	.4	.05	8	NW	7
Jan. 24, a. m	3.5	.37	10	NW	15
Jan. 24, p. m	.3	.03	10	N	17
Feb. 18	.5	.03	16⅔	SE	12
Feb. 19, a. m	2.0	.12	16⅔	SE	12
Feb. 19, p. m	.75	.10	7.5	NE	12
Mar. 5	2.25	.11	20	N	25
Mar. 8	1.13	.03	42	N	6

The snows of the winter were very light as shown by Table 1. The average ratio of all of the snows measured was 14 to 1, somewhat higher than the generally accepted value of 10 to 1.

In the first snow the rain-gage can measurement was about 50 per cent of the snow board measurement. It was thought that this might be due to the difference in height of the two. The greater amount on the snow board being due to drifting.

To determine the influence of height two battery jars 8 inches high, the 8-inch receiver top about 10 inches high, the 12-inch receiver top about 10 inches high, were arranged about the rain-gage can as shown by the diagram.

Table 2 shows the amount caught in each. The amount by weighing and the amount by melting and measuring as rain are both given. The slight variation in the two values may be credited to evaporation during melting.

TABLE 2.—*Comparison of snowfall measurements at Grand Forks*

[T indicates less than 0.01 inch]

Date	Gage can		8-inch "cut"		12-inch "cut"		8-inch receiver	
	Weight	Stick	Weight	Stick	Weight	Stick	Weight	Stick
Jan. 19, a. m	T	T	0.01	0.01	0.01	T		
Jan. 23, p. m	0.02	0.02	.05	.05	.05	0.05		
Jan. 24, a. m	.19	.18	.37	.36	.37	.37	0.34	0.33
Jan. 24, p. m	.03	.03	.03	.03	.026	.03	.03	.03
Jan. 27, p. m	T	T	.01	.01	.01	.01	.01	T
Feb. 18, p. m	.01	.01	.02	.01	.03	.01	.01	.01
Feb. 19, a. m	.05	.04	.14	.13	.11	.10	.035	.02
Feb. 19, p. m	.04	.04	.10	.10	.11	.10	.056	.06
Mar. 5, p. m	.11	.10	.11	.10	.11	.11	.11	.10
Total	.45	.42	.84	.80	.83	.78		

Date	12-inch receiver		Jar I		Jar II	
	Weight	Stick	Weight	Stick	Weight	Stick
Jan. 19, a. m						
Jan. 23, p. m						
Jan. 24, a. m	0.34	0.34	0.44	0.42	0.38	0.36
Jan. 24, p. m	.029	.03	.029		.03	
Jan. 27, p. m	.01	T		T		T
Feb. 18, p. m						
Feb. 19, a. m.			.14		.15	
Feb. 19, p. m			.08		.10	
Mar. 5, p. m						

Mean of totals by standard rain-gage overflow can, 0.435 inch, melted.
Mean of totals by Horton snow board, 0.81 inch, melted.
Ratio of snow board to gage can, 1.86.

The variation between all except the can was slight and might be credited to wind gusts and drifting. All of the measurements are nearly double those of the can. From this it would appear that some other factor besides the height of the measuring devices causes the deficiency in the can.

The snow season this year was short and only a few real heavy snows occurred. However, measurements were taken on most of them throughout the winter. The can measurements are consistently below those of the snow board and the other devices used to catch the snow. In no case did the amount in the can exceed the amount caught on the snow board and in only two cases did it equal it.

In the light snows the measurements by both methods were very close, but in the heavier snows the snow-board measurement was about twice that of the gage can.

Measurements were taken during various wind velocities. Although these velocities bear no direct relation to the snow ratio, there seems to be some relation between them and the amounts caught on the snow board and in the gage can. In the two cases when the amoun tin the can equalled the amount caught on the board the wind velocities were the highest. In one case the

velocity was 17 miles per hour and in the other case it was 25 miles per hour. In all other cases it was not over 15 miles per hour.

The temperature was well below freezing during the precipitation of all the snows listed in Table 2.

Referring to Table 2 we find that the total amount recorded by the rain-gage can was 0.435 inches and that of the snow board to be 0.81 inches, or 1.86 times that recorded by the gage can. In a seasonal snowfall of 32 inches, which is the average for Grand Forks for a period of 31 years, the deficiency would be 27.5 inches or taking it over the 31 year period, the total deficiency would be 738.6 inches, if rain-gage can measurements have been strictly adhered to in the past measurements.

TWILIGHT PHENOMENA ON MONT BLANC

E. BAUER, A. DANJON and JEAN LANGEVIN

(Comptes Rendus, 178, no. 25, June 16, 1924, pp. 2115–17)

[Translated by B. M. Varney, Weather Bureau]

We have studied the twilight phenomena at the Vallot Observatory on Mont Blanc (4,347 meters) under excellent, perhaps even exceptional, atmospheric conditions. Observations first undertaken in August, 1922, have been carried out from the 9th to the 14th of August, 1923. The interesting thing about a study at this altitude is the extreme simplicity and the almost astronomic regularity of the phenomena. Certain phases described in the standard works [1] were, however, missing. It is likely that the complications observed at a low altitude are in large measure the result of conditions in the dusty lower layers of the atmosphere, which extend upward to 3,000 to 3,500 meters.

1. *Phenomena opposite the sun. The earth's shadow.*—At 180° from the sun, one sees the shadow of the earth on the atmosphere; this is the ascent of night (la montée de la nuit), a blue-black segment bordered with purple in its upper part.

TABLE 1.—*Altitude of the blue segment (a. m.)*

$h_{\odot}$ = true solar altitude	0°	−2°	−4°	−5°	−6°
Altitude of the segment	−2°	+2°	+7°30′	+15°	+26°

NOTE.—The dip of the horizon at Vallot observatory is −2°.

The boundary of the segment is lost before it reaches the zenith and when the solar altitude h. = −7°.

The intersection of the solar ray which is tangent to the earth with the straight line from the observer to the summit of the segment, describes an elliptical arc leaving the earth at a distance of 100 kilometers [from the observer] and reaching the zenith at an altitude of about 45 kilometers.

2. *Phenomena observed on the side toward the sun. We have seen no evidence of the first twilight arch (9° from the sun), nor of the purple lights.*—Photographic records confirm these negative conclusions. The only one of the phenomena observed with great regularity is the second twilight arch: at the horizon a reddish segment, above that a yellow segment, and finally a much larger segment of a greenish blue very pure in tone, its upper boundary rather sharply drawn, and above it the night. This varicolored segment appears, to us to constitute a wholly unique thing, differing widely from that which one infers from the standard descriptions, which are mostly confused and contradictory.

It appears to be useless to make a distinction between the reflected light of twilight (the Dämmerungsschein of Pernter-Exner) [2] and the twilight arch properly so called.

TABLE 2.—*Altitudes of the twilight arch (p. m.)*

$h_{\odot}$	8°	10°	12°	14°	17°50′
Red/yellow boundary	−1°10′	−1°	−0°55′	−0°45′	------
Yellow/blue boundary	+0°40′	+0°30′	+0°10′	0°	------
Blue/night boundary	+10°	+7°30′	+4°35′	+2°20′	−2°

The boundary of the twilight arch (blue/night) passes the zenith at a solar altitude of −4° 40′. It is thus a phenomenon independent of the ascent of night, the edge of which attains the zenith only when the solar altitude is −7° or −8°. The arch disappears completely at h.= −17° 50′.

It seems to us impossible to explain the twilight arch on the basis of a reflection of the purple light as Pernter and Exner have done.[3] It appears more likely that it is due to diffusion of direct sunlight by the atmosphere included between the shadow cone of the earth and a certain limiting altitude z. But if we compute z, we obtain numbers which increase as the sun declines.

TABLE 3.—*Altitude of the twilight arch (p. m.)*

$-h_{\odot}$	4°35′	10°	14°	16°	17°
z (km.)	14	30	39	42	44

It is to be observed that the measurements of the twilight arch and of the ascent of night give the same altitude for the highest diffusion layers, about 45 kilometers.

We have observed 30 minutes after the setting of the twilight arch, a new luminous segment, very faint, fairly well defined but irregular, which disappeared little by little below the horizon.

This segment, which does not seem to be due to the zodiacal light, is perhaps a third twilight arch. Its summit is at about 9° altitude when $h_{\odot} = -21°$. The diffusion layer which would cause it would therefore reach 180 kilometers altitude and would be identical with the absorptive layer observed by us in 1922.[4]

3. *Photometric measurement of the brightness of the zenithal sky.*—The measurements were carried out according to the photometric method of Fabry,[5] slightly

[1] Pernter and Exner, Meteorologische Optik, 2d ed., 1922, p. 845 et seq.
[2] loc. cit., p. 856.

[3] loc. cit., p. 898.
[4] Comptes Rendus, 176, 1923, p. 761.
[5] The Director of the Bureau of Standards, Washington, D. C., has kindly contributed the following comment on the nature of the Fabry photometric method.

"While the reference to method of measurement is somewhat indefinite, we judge that it refers to a type of photometer described by H. Buisson and Charles Fabry in the Journal de Physique, page 25, 1920. A brief description of this instrument is also given in abstracts printed in the Transactions of the Illuminating Engineering Society, volume 16, page 92, 1921. This instrument is designed particularly for the measurement of very faint sources, and apparently it can be used for the direct comparison of the light from a small source with that for a luminous area. For example, it would make possible the direct comparison of the light from a star with that of a given area of the sky, and it would then be possible to express the brightness of a given region in terms of the intensity of a single star such as Vega. This would involve simply an estimate or a determination of the solid angle included in the field of view of the photometer, and evidently the authors have expressed this solid angle in a unit which they call a 'degree square.'"

modified. The absolute values of the brightness M, expressed in [star] magnitudes per degree square, have been determined with reference to Vega $0^{m}.14$ as unity.[6]

TABLE 4.—*Brightness of the zenithal sky*

$h_{\odot}$	−7°	−9°	−11°	−13°	−15°	−16°
M	$-3^{m}.0$	$-1^{m}.35$	$+0^{m}.25$	$+1^{m}.80$	$+3^{m}.10$	$+3^{m}.65$
$h_{\odot}$	−17°	−18°	−20°	−25° to −29°		
M	$+4^{m}.00$	$+4^{m}.10$	$+4^{m}.20$	$+4^{m}.27$		

Beyond $h_{\odot}=-18°$, the brightness remains virtually constant, the brightness found agreeing with those of the nocturnal sky. Since they were obtained very close to the plane of the Milky Way, in the constellation Cygnus, they are doubtless a little too large.

It is clear that the end of twilight at the zenith coincides with the setting of the second twilight arch, at $h_{\odot}=-17°\ 50'$. Hence the two phenomena are related. The twilight arch diffuses the direct light of the sun a first time; this is then reflected once again by the atmosphere of the zenith.

In support of this explanation we may cite the parallelism, without any abscissal lag (décalage d'abscisse), between the curve found by us for the zenith and that which has been obtained by Fessenkopf for 70° zenith distance in the azimuth of the sun.

[6] Superior *m* as here used stands for star magnitudes, expressed decimally.

NOTES, ABSTRACTS, AND REVIEWS

George Titus Todd, 1866-1924

George T. Todd, meteorologist, died at Albany, N. Y., on November 12, 1924. His death was due to a sudden attack of acute dilation of the heart and occurred within 12 hours after he had delivered a lecture on the weather at the Mount Ida Memorial Presbyterian Church at Troy, N. Y.

Mr. Todd entered the Signal Corps on January 4, 1887, and after the usual preliminary course of instruction was assigned as a clerk at the central office at Washington, D. C., and afterwards as assistant at Detroit and Port Huron, Mich., and Memphis, Tenn. He was in charge of the station at Dodge City, Kans., from February, 1890, until November, 1902; at Wichita, Kans., from November, 1902, until May 3, 1905; and at Albany, N. Y., from May, 1905, until the time of his death.

Mr. Todd served the country continuously for 38 years with credit to himself and the Weather Bureau, and with great benefit to those for whom he especially labored. He was a very efficient member of our organization, faithful, conscientious, and courteous in all his undertakings and associations, and an honored and respected member of the communities in which he served. He was not only a Federal official; he was a citizen of the communities in which he lived. He devoted much of his time to them, and their interests were his interests.

In Albany Mr. Todd's skill and judgment in handling the complex flood problems in the spring, the heavy snows and cold waves of winter long ago made his name a household word throughout eastern New York, and his genius in these respects was the means of saving many millions of dollars to the business interests of that congested district.

Mr. Todd left a wife, a son, a daughter-in-law, and a grandson. He was a member of the Masonic fraternity and he was also a prominent member of the Rotary Club of Albany. Perhaps his most distinctive personal characteristics were his unfailing optimism and cheerfulness. These were never wanting, whether he was engaged in forecasting a flood, in cultivating roses, perhaps his best loved diversion, or in promoting the welfare of his fellow man. His associates in the Weather Bureau and the people of Albany and vicinity will hold his name in affectionate memory. (H. C. F.)

GRASSLAND AS A SOURCE OF RAINFALL [1]

F. E. CLEMENTS

In the endeavor to secure a definite correlation between grassland and rainfall, the various associations, such as true prairie, mixed prairie, etc., have been used as indicators of the amount of precipitation. It has been assumed that typical grassland develops only under summer rainfall, but this is incorrect, as the bunch-grass prairie of the Pacific coast corresponds to a winter rainfall, and the desert plains of the Southwest to a two-season or a summer-winter rainfall. In short, the amount of precipitation and evaporation rather than their calendar occurrence, seem to be the controlling factors.

The fact that a plant may transpire more water than a water body of equal surface evaporates, led to experiments to measure the transpiration of representative prairie communities. This was done by incasing sods in 3-foot cylinders without disturbing the roots and weighing these at the desired intervals in the true prarie, mixed prairie and short-grass plains, with annual mean rainfall, respectively, of 28, 23, and 17 inches. It was found that the transpiration in each community was more than equal to the precipitation occurring on it during a year. At Lincoln in the true prairie and Phillipsburg in the mixed prairie the transpiration was about 60 inches for the six-month growing season. This was approximately twice the mean rainfall and somewhat less than twice the evaporation from a free water surface. At Burlington in the short-grass plains, the transpiration for the four-month season was 40 inches or about twice the rainfall and somewhat less than the evaporation.

The cereal crops were found to transpire at about the same rate as the native grasses, while alfalfa lost somewhat more water. The water-loss from the native wheat-grass nearly equaled that from millet, while at Phillipsburg the loss from grama and from oats was the same, with bluestem transpiring nearly twice as much. The loss from alfalfa at Lincoln was about a third greater than that from bluestem. The results explain why ordinary settlement and cultivation have not increased rainfall, but suggest that afforestation over wide stretches would do so.

[1] Read at meeting of American Meteorological Society, Leland Stanford University, June 26, 1924.

PERIODICITIES, SOLAR AND METEOROLOGICAL

By C. CHREE

[Reprinted from Science Abstracts, 1924, no. 2688. See Jour. Roy. Meteorolog. Soc., 50, pp. 87-97, April, 1924]

An address, delivered before the Royal Meteorological Society, in the first part of which sun-spot frequencies for the years 1856 to 1921 from Wolfer's lists are compared by various methods with mean yearly values of data relating to Kew Observatory, comprising rainfall, mean temperature, daily range of temperature, sunshine, cloud, mean potential gradient, absolute daily range of magnetic declination, and diurnal inequality range of declination and horizontal force for such periods as they are available. The points which the writer wishes to bring home to meteorologists are the two facts: (1) That an important sun-spot relation does exist in at least one terrestrial element—terrestrial magnetism; (2) that, at least in these latitudes, the evidence for a connection between sun-spot frequency and meteorological phenomena is of quite a different order from the evidence for a connection between sun-spot frequency and terrestrial magnetism.

The considerations put forward amply illustrate the danger of drawing conclusions in such matters as the present from data extending over an insufficient period of time. In the latter part of the paper the author is able, however, to suggest for trial a method by which relationships between sun-spot frequencies and terrestrial elements might be investigated, even though data for the latter may not be available for a number of 11-year periods. Reasons are given for supposing that the difference between magnetically quiet and disturbed days is essentially of the same nature as the difference between quiet days at sun-spot minimum and quiet days at sun-spot maximum. Granting this, any meteorological or electrical element which exhibits the 11-year period will, it is reasonable to suppose, behave differently on days that are magnetically quiet and on days that are magnetically disturbed. The suggestion is, then, that the meteorological data relating to the two classes of days, as well as the electrical data, should be compared at a number of places, it being noted in this connection that the international lists issued from De Bilt will in future specify five disturbed days a month as well as five quiet days. It is shown to be desirable to commence with places in high magnetic latitudes as being most likely to yield best results.—*M. A. G.*

TORNADO CLOUDS

By CLARENCE J. ROOT

[Weather Bureau, Springfield, Ill., December 1, 1924]

An article by Mr. Varney in the August, 1924, number of the MONTHLY WEATHER REVIEW discusses the tapering shape of the damaged area in connection with the tornado at Lorain, Ohio, June 28, 1924. Figure 2 shows the relation of decreasing area at the earth's surface to the rise of the funnel cloud.

This brings to mind the so-called Mattoon tornado of May 26, 1917. The path of this storm was perhaps the longest of record, extending across the entire State of Illinois and three-fourths of Indiana, a distance of 293 miles. Across the State from the Mississippi River almost to Mattoon all eyewitnesses agreed that this storm had the typical funnel-shaped tornado cloud with swinging tail, and east of Charleston the same type of cloud was reported, but the writer who visited Mattoon and Charleston, failed to find anyone in those cities who saw a funnel-shaped cloud. Eyewitnesses who had an unobstructed view agreed that the approaching storm appeared as a low, boiling mass of clouds, one part a little to the north and the other a little to the south. The parts seemed to roll toward one another, coming together and downward like the meshing of a pair of cog wheels. In the official report it was suggested that the cloud was so low that there was no room for the usual pendant portion. The path of serious damage was generally about one-fourth mile in width.

There was ample evidence of tornadic action in Charleston and Mattoon. A barograph trace showed a tornado dip, buildings "exploded," the walls falling outward, and the directions in which the trees lay were typical of the true tornado. The direction of movement was a little north of east. The southern limit of the zone in which the trees fell to the west coincided exactly with the northern limit of the zone of complete destruction. This indicates that the greatest wind force occurred on the south of the actual center of the whirl.

HUMIDITY RECORDERS

By E. B. WHEELER [1]

[Reprint from Science Abstracts, section A, October 25, 1924, No. 2410]

The material effect of atmospheric conditions upon the operation of intricate electrical and mechanical apparatus, such as is found in telephone systems, is discussed, and the desirability of obtaining accurate information as to the character of the atmospheric conditions obtaining in typical localities is emphasized. The specific advantages and limitations of various well-known types of hygrometers are reviewed and the development of a new recording hygrometer is described in which the Leeds and Northrup automatic recorder is employed in conjunction with wet and dry bulb resistance thermometers in an auxiliary wind-tunnel equipment and a specially designed double Wheatstone bridge circuit. One of the Wheatstone bridges contains the dry bulb thermometer, the other containing both the dry and wet bulb thermometers. The satisfactory performance of a number of such instruments is illustrated in typical graphs. A new direct-reading humidity recorder is also described working on a similar general principle, and depending for its operation upon the approximate linearity and common intersection of the ordinary humidity curves connecting wet and dry bulb temperatures for a given relative humidity.—*A. B. C. L.*

EDITOR'S NOTE.—An examination, by the Instrument Division of the Weather Bureau, of the original paper, indicates that the recorder described is probably more precise than any other which has come to the attention of the division. On the other hand, it is believed to be too expensive and complicated for general meteorological work. Readers of the REVIEW will, however, be interested to know of the existence of this instrument of high precision.

THE CAUSE OF CYCLONES

By A. H. R. GOLDIE, Edinburgh

[Reprint from Nature, 114: November 29, 1924, pp. 786-787]

In the winter of 1922-23 there appeared in Nature some correspondence on "The cause of anticyclones," and on that occasion I put forward certain views as to the mechanism by which the more rapid increases

[1] Bell System Techn. Jour., 3, pp. 238-258, April, 1924.

of barometric pressure are brought about in temperate latitudes (Nature of March 31, 1923, pp. 429–430). The present communication may be regarded as a sequel in that its object is to describe a mechanism by means of which the more rapid reductions of pressure can conceivably be produced. The idea arises naturally from consideration of a series of papers by Helmholtz appearing in the Sitzungsberichte of the Royal Prussian Academy of Sciences in 1888 and 1889, dealing with the equilibrium of rotating rings of air at different temperatures, and with the theory of winds and waves where strata of different density lie contiguous with one another.

The conditions for equilibrium in cases where a surface of discontinuity (of temperature and wind) exists in the atmosphere have since that time been dealt with by V. Bjerknes and others in somewhat more general fashion and need not be set out here.

Designating the warmer (southerly) mass by (1) and the colder (northerly) by (2), Helmholtz calculates in terms of their velocities, temperatures, and the latitude the theoretical slope of the bounding surface for a state of stable equilibrium. But, as he points out, first small waves and then mixing of the two media must soon occur over this boundary; he therefore calculates the slope for stability of the bounding surface between mass (2) and the mixture and between the mixture and mass (1). He shows that these slopes are respectively more acute and less acute (relatively to the horizon) than the original slope between mass (2) and mass (1). Hence, he says, results the important consequence that (in tending toward the new requirements for equilibrium) "all newly formed mixtures of strata that were in equilibrium with each other must rise upward between the two layers originally present, a process that of course goes on more energetically when precipitations are formed in the ascending masses. While the mixed strata are ascending, those parts of the strata on the north and south that have hitherto rested quietly approach each other until they even come in contact, by which motion the difference of their velocities must necessarily increase since the strata lying on the equatorial side acquire greater moment of rotation (about the earth's axis) with smaller radius, while those on the polar side acquire feebler rotation with a larger radius."

Now the importance of this reasoning, applied in the light of modern meteorological knowledge, appears to me enormous. Putting aside for the moment all theories as to the origin of cyclones, it appears to be pretty well established by the facts of observation that the normal structure of an active and recently formed depression at least approximates to that described by Bjerknes.

Further, observation tends to confirm (1) that the principal reduction of pressure and the principal area of rainfall lie at any moment within the "old" cold air in front of the Bjerknes steering line, (2) that where the warm air extends right down to the ground no appreciable pressure-change is taking place, unless quite close to the steering line, (3) that, where the "new" cold air is undercutting the warm air, there is rapidly rising pressure.

I have shown elsewhere that the rise of pressure in the new cold air and the comparative constancy of pressure in the warm air and also the temperatures of these masses are consistent (dynamically) with their (supposed) northerly and southerly origins and with the processes to which they have been subjected in arriving on the field of operations; and further that the changes in the energy (potential, kinetic and internal) of the "new" cold current are sufficient to account for the work that is being done by it in displacing the warm air and filling up the rear of the depression. But I have never previously been able to see why in front of the depression the warm air should mount upon the old cold air, or why, if it did so, a fall of pressure should at the same time occur in the region below; though I have indeed been able to find evidence that a selected mass within the warm air was continually approaching a selected mass within the old cold air. Now, if the Helmholtz reasoning is sound, we can make an important step forward. The mysterious "eviction of air," as Sir Napier Shaw has called it, is accomplished by the continual procession of the products of mixing of the warm and cold up a kind of giant escalator—with a moving roof as well as steps—hitherto described usually as the steering surface; and the process would go on so long as any warm sector remained.

At the moment, I can see no fact of observation that is inconsistent with such a theory, and it further appears to lead to feasible energy equations for the front half of a cyclone.

In the problem dealt with by Helmholtz the "eviction" and the subsequent "dumping" of the air do not seriously enter, and beyond the remarks quoted above, he devotes no consideration to either. As to the latter, steering surfaces appear to extend up to the level of the highest clouds and even into the stratosphere, and their inclination to the horizon appears to be of the order of 1:100. Hence the dumping need not take place within 1,000 kilometers of the steering line and may be spread over an enormous area beyond that. The tracks of the most frequent North Atlantic depressions lie roughly parallel to the line of the (eastern) American and Greenland coasts, and in a belt about 1,000 to 2,000 kilometers distant from these coasts. The tracks of the North Pacific depressions are somewhat similarly situated with regard to Siberia. Of all places in the Northern Hemisphere the North America-Greenland area and Siberia would most welcome the dumping of surplus air and most of all at those seasons when depressions are most active. For these areas must be receiving air—probably at a high level—to compensate for the constant vertical contraction of the film of atmosphere there by cooling and for the recurrent discharges of cold air into the rear of passing depressions. In this way depressions might perhaps be regarded as the heat-receiving ends of thermosyphonic arrangements, the corresponding radiating ends being areas like North America, Greenland, Siberia, or the Antarctic continent; both ends being necessary for the maintenance of the circulations. A secondary depression and its "dying" parent would perhaps bear a similar relation one to another. In all cases the principal supply of heat would be borne from equatorial regions by warm currents of high water vapor content. Given sufficiently complete synoptic weather charts of the Northern Hemisphere, to test the above theory by a combination of the facts of observation, hydrodynamics and thermodynamics would not, I think, be impossible, though the task would be one of some magnitude.

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Shaw, H. Knox.
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Situation, dans l'espace, deque lques aurores boréales. Paris. [1920.] 7 p. illus. 25 cm. (Extr.: Bull. de la Soc. astron. de France, avr., 1920.)

Taihoku, Meteorological observatory.
Weather forecasts and storm warnings. Taiwan. 1924. [2 p.] 33½ cm.

Union of South Africa.
Frost map. Pretoria. 1922. 3 maps. 25½ x 34 cm.

Union of South Africa. Meteorological office.
Code and instructions for weather messages from land stations. Pretoria. 1924. 21 p. plates. 24½ cm.

Wheeler, E.B.
Humidity recorders. p. 238–258. figs. 25½ cm. [Exc.: Bell system tech. journ. v. 3, no. 2, Apr., 1924.]

Wüst, Georg.
Florida- und Antillenstrom; eine hydrodynamische Untersuchung. Berlin. 1924. 48 p. illus. plate (fold.). 26 cm. (Veröff. des Instituts für Meereskunde, Univ. Berlin. Neue Folge, A. Geographisch-naturwissenschaftliche Reihe. Heft 12. Juli, 1924.)

RECENT PAPERS BEARING ON METEOROLOGY

The following titles have been selected from the contents of the periodicals and serials recently received in the library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

Annalen der Hydrographie und maritimen Meteorologie. Berlin. 52. Jahrgang. September 1924.

Edlund, O. Die Trift des "Conrad Holmboe" im Ostgrönlandeis, August-Oktober 1923. p. 207–210. [Describes meteorological services in Spitsbergen, Greenland, etc.]

Kähler, K. Die atmosphärische Elektrizität über den Meeren. p. 201–207.

Petersen, P. Die Eisverhältnisse an den deutschen Küsten während des Winters 1923/24. p. 213–220.

California citrograph. Los Angeles. v. 10. November, 1924.

McEwen, George F. Forecasting seasonal rainfall from ocean temperatures. p. 39.

McPhee, Douglas. Fighting the forces of frost at Limoneira, p. 4; 34–35.

Young, Floyd D. Fruit thermometers in orchard heating for oranges. p. 2.

France, Académie des sciences. Comptes rendus. Paris. t. 179. 1924.

Rempp, G., & Lacoste, J. Nouvelle étude sur la variation diurne de la direction du vent à Strasbourg. p. 695–698. (16 oct.)

Hueguenard, E., Magnan, A., & Planiol, A. Sur la variation de la vitesse du vent avec l'altitude, au voisinage du sol. p. 1067–1070. (17 nov.)

Guilbert, Gabriel. Sur un cas de destruction de cyclone. p. 1182–1183. (24 nov.)

Schereschewsky, Ph., & Wehrlé, Ph. Les pseudo-fronts polaires. p. 1183–1186. (24 nov.)

Geographische Zeitschrift. Leipzig. 30. Jahrgang. 4. H. 1924.

Gradmann, Robert. Die postglazialen Klimaschwankungen Mittel-Europas. p. 243–263.

Japanese journal of astronomy and geophysics. Transactions and abstracts. Tokyo. v. 2. no. 2. 1924.

Nukiyama, Daizo. On the theory of monsoon rainfalls in the Far East. p. 75–90.

Nature. London. v. 114. Nov. 1, 1924.

Harrison, E. P. Microseisms and storm forecasts. p. 645.

Larmor, Sir Joseph. Why wireless electric rays can bend round the earth. p. 650–651.

Società meteorologica italiana. Bollettino bimensuale. Torino. v. 44. Ottobre-dicembre 1924.

Bonacini, G. Fenomeni di ottica atmosferica. p. 71–78.

Crestani, G. Il vento delle quote superiori come sussidio nella previsione del tempo. p. 69–71.

Eredia, Filippo. Alfredo Angot. p. 79–80. [Obituary.]

SOLAR OBSERVATIONS

SOLAR AND SKY RADIATION MEASUREMENTS DURING NOVEMBER, 1924

By HERBERT H. KIMBALL, In Charge Solar Radiation Investigations

For a description of instruments and exposures, and an account of the method of obtaining and reducing the measurements, the reader is referred to the REVIEW for January and February, 1924, **52:** 42 and 113.

From Table 1 it is seen that solar radiation intensities averaged slightly above the normal for November at Washington, close to normal at Madison, and slightly below normal at Lincoln.

Table 2 shows a deficiency in the total radiation received on a horizontal surface at Washington and Madison and a slight excess at Lincoln.

Skylight polarization measurements made on five days at Washington give a mean of 62 per cent, with a maximum of 64 per cent on the 17th. Measurements made on two days at Madison give a mean of 65 per cent, with a maximum of 66 per cent on the 1st. These are close to November average values for Washington but below November averages for Madison.

TABLE 1.—*Solar radiation intensities during November, 1924*

[Gram-calories per minute per square centimeter of normal surface]

Washington, D. C.

Date	8 a.m.	Sun's zenith distance 78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass A. M.					P. M.				Local mean solar time
	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
Nov. 1	8.18	0.63	0.76	0.99	1.22	1.50	1.24	1.02	0.84	0.74	7.04
12	9.14				0.99						8.48
14	12.68				1.19						5.36
17	2.26	1.01	1.12	1.20	1.44		1.44	1.19			1.88
19	2.49				0.97		0.97	0.76	0.60		2.36
20	3.45	0.94	0.85	0.99	1.25			1.07			4.95
26	3.30	0.87		1.04	1.32			1.16	1.01	0.82	2.74
28	4.17			1.05							3.45
Means		0.81	0.91	1.05	1.20		1.22	1.04	0.82	0.78	
Departures		+0.07	+0.06	+0.06	+0.03		+0.06	+0.07	±0.00	+0.06	

* Extrapolated.

TABLE 1.—*Solar radiation intensities during November, 1924*—Con.

Madison, Wis.

Date	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
Nov. 1	4.95	0.91	0.99	1.13	1.30	1.49					5.16
4	3.15			1.19	1.33						3.45
12	2.87	0.99	1.13	1.26	1.43	1.61		1.26			3.63
15	2.87		0.84	1.07							3.63
19	3.30	0.83	0.97	1.12	1.34		1.31				4.95
20	5.36							1.10			6.50
Means		0.91	0.98	1.15	1.35		(1.31)	(1.18)			
Departures		+0.03	−0.03	−0.01	+0.05		−0.03	+0.01			

Lincoln, Nebr.

Date	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
Nov. 1	3.63			1.15	1.38						3.30
7	2.87						1.39	1.09			3.45
8	3.00	0.87	0.97	1.10	1.26	1.43					3.63
15	3.15							1.21	1.08	0.97	3.99
17	3.99	1.07		1.27	1.38						4.17
18	3.30						1.42	1.24	1.12	1.02	3.81
19	4.57	0.92	0.99	1.12	1.26						5.16
20	6.76	0.87	0.96	1.06							5.56
21	3.00	0.99	1.09	1.22	1.32			1.09			3.30
25	2.26		1.09	1.26							2.06
Means		0.94	1.02	1.16	1.33		(1.40)	1.16	(1.10)	(1.00)	
Departures		±0.00	−0.03	−0.03	−0.03		−0.03	−0.04	−0.05	−0.06	

* Extrapolated.

TABLE 2.—*Solar and sky radiation received on a horizontal surface.*

[Gram-calories per square centimeter of horizontal surface]

Week beginning—	Average daily radiation: Washington	Madison	Lincoln	Chicago	New York	Average daily departure from normal: Washington	Madison	Lincoln
	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
Oct. 29	228	233	292	184	210	−17	+46	+44
Nov. 5	172	119	252	88	151	−51	−50	+20
12	188	135	234	90	171	−11	−14	+19
19	150	109	193	72	117	−26	−25	−9
26	168	132	187	91	143	+10	+7	−1
Excess or deficiency since first of year on Dec. 2, 1924						+634	−7,280	+3,370

WEATHER OF NORTH AMERICA AND ADJACENT OCEANS

NORTH ATLANTIC OCEAN

By F. A. YOUNG

The following table shows the average sea-level pressure for the month at a number of land stations on the coast and islands of the North Atlantic. The readings are for 8 a. m., 75th meridian time, and the departures are only approximate, as the normals were taken from the Pilot Chart and are based on Greenwich mean noon observations, which correspond to those taken at 7 a. m., 75th meridian time.

Station	Average pressure	Departure
	Inches	*Inches*
St. Johns, Newfoundland	29.91	−0.02
Nantucket	30.05	−0.04
Hatteras	30.13	0.00
Key West	30.07	+0.04
New Orleans	30.19	+0.09
Swan Island	29.88	−0.05
Turks Island	29.97	−0.04
Bermuda	30.12	+0.04
Horta, Azores	30.22	+0.11
Lerwick, Shetland Islands	29.91	+0.21
Valencia, Ireland	29.95	+0.05
London	30.07	+0.12

At Horta the barometric readings ranged from 29.98 inches on the 1st and 7th to 30.50 inches on the 19th, and at Lerwick from 29.11 inches on the 2d to 30.46 inches on the 12th.

November, taken as a whole, was an unusually stormy month on the North Atlantic, especially over the middle and eastern sections of the steamer lanes, where winds of gale force were reported on from six to nine days, which is considerably in excess of the normals as shown on the Pilot Chart. There were also disturbances of tropical origin, described elsewhere in the REVIEW.

Fog was exceptionally rare over the northern division of the ocean, the greatest frequency occurring in the 5-degree square between the 40th and 45th parallels and the 45th and 50th meridians, where it was reported on five days. Fog was reported on four days, however, in the western part of the Gulf of Mexico, which is unusual for that locality, where it is ordinarily rare.

On the 1st and 2d a fairly well-developed disturbance covered a portion of the eastern section of the steamer lanes; this moved rapidly eastward and on the 2d covered the North Sea. At the time of observation on both the 1st and 2d westerly winds of force 7 to 8 were encountered by vessels in the southerly quadrants.

On the 3d there was an area of low pressure in the vicinity of Nova Scotia that traveled northeastward and on the 5th was off the north coast of Newfoundland. On the 3d and 4th westerly to northwesterly gales prevailed over the region between the Bermudas and Newfoundland and on the 4th and 5th winds of gale force were reported by vessels in widely scattered positions.

On the 7th there was a well-developed LOW central about 300 miles north of the Azores that traveled northward, and on the 8th the center was near 50° N. and 30° W.; it then curved sharply toward the east and on the 10th was over the region between the 20th meridian and the coast of Ireland.

Charts VIII to XIII show the conditions from the 9th to 14th, inclusive, when a tropical disturbance prevailed in southern waters, while during the same period the middle and eastern sections of the steamer lanes were swept by exceptionally severe gales of extra-tropical origin.

On the 8th strong westerly gales prevailed in the Gulf of St. Lawrence, although it was impossible to plot the positions of this disturbance, due to lack of observations.

On the 9th, as shown on Chart VIII, abnormally high pressure prevailed off the New England coast with the crest near Portland, Me. Vessels between the 40th and 45th parallels and the 55th and 60th meridians reported northwesterly gales accompanied by comparatively high pressure.

On the 15th a well-developed disturbance of limited extent was central near 50° N., 45° W.; this moved rapidly eastward and by the 16th the center had reached a position near 50° N., 30° W. A number of vessels in the vicinity of this LOW encountered moderate to strong gales; the storm area on the 15th extended as far south as the 35th meridian and on the 16th extended over the region between the 30th meridian and coast of northern Europe.

On the 16th there was a comparatively slight depression central about midway between Bermuda and Nantucket; this developed rapidly as it moved northeastward along the coast, being in the vicinity of Newfoundland on the 17th and 18th. It reached its greatest intensity on the 17th, the storm area on that date covering the region between the 35th and 45th parallels and 40th meridian and American coast.

From the 19th to 21st moderate weather was the rule over the ocean with the exception of a slight disturbance on the 19th and 20th in the vicinity of the Straits of Gibraltar, and a second of like character on the 20th and 21st in the region between the 40th and 45th parallels and the 50th and 55th meridians. There was also a shallow depression on the 21st in the Gulf of Mexico that afterwards developed into a severe disturbance as it moved northeastward along the American coast, reaching its greatest intensity on the 23d, when moderate to strong gales were encountered between the 25th and 50th parallels and 60th and 75th meridians.

On the 24th there was a LOW over the eastern section of the steamer lanes; it moved slowly eastward, gradually increasing in intensity until the 28th, when the maximum was reached, and from the 26th until the end of the month violent storms were encountered by vessels between the 40th meridian and the European coast.

On the 25th and 26th abnormally high pressure was reported by land stations on the north coast of the Gulf of Mexico, while on the former date the pressure at Swan Island was practically normal, and on the latter slightly above. The steep pressure gradient was responsible for strong northerly winds in the intermediate territory.

On the 25th a shallow depression was central near 33° N., 52° W.; it deepened somewhat on its northward track, the center on the 26th being near St. Johns, Newfoundland.

On the 29th there was a LOW between Hatteras and New York, which increased in intensity rapidly during the next 24 hours, the center on the 30th being near Halifax, Nova Scotia. Beginning on the afternoon of the 29th and extending until the 30th, severe northwesterly gales prevailed over a limited area between the 35th and 40th parallels and 45th and 50th meridians.

Storm logs from vessels that encountered severe weather during the month will be found in the accompanying table, although lack of space prevents giving more than a small fraction of all reports received.

Table of ocean gales and storms

Vessel	Voyage		Position at time of lowest barometer		Gale began	Time of lowest barometer	Gale ended	Lowest barometer (ins.)	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Highest force of wind and direction	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
North Atlantic Ocean			° ′	° ′									
Republic, Am. S. S.	England	New York	51 00 N.	18 10 W.	1st	6 a., 1st	8 p., 1st	29.23	S	WSW	W	—, 9	S-WSW-W.
Wieldrecht, Du. S. S.	Pensacola	London	36 10 N.	70 03 W.	3d	2 a., 3d	4th	29.99	NW	NW., 10	NW	NW., 10	NW-WNW.
Oscar II, Dan. S. S.	Christiania	New York	53 44 N.	31 48 W.	5th	Noon, 5th	5th	29.34	S	SSE., 9	W	SSE., 10	SSE-SW-W.
West Inskip, Am. S. S.	Antwerp	Boston	42 16 N.	24 11 W.	7th	4 p., 7th	8th	29.59	SE	SW., 8	NW	NW., 9	SE-NW.
Andalusier, Belg. S. S.	Norfolk	Antwerp	46 31 N.	31 44 W.	8th	4 a., 8th	9th	29.73	NW	NW., 8	SW	NW., 12	Steady NW.
Independence Hall, Am. S. S.	Havre	New York	49 30 N.	17 30 W.	7th	4 p., 9th	10 a., 11th	29.20	E	WNW., 9	WNW	WNW., 11	SSW-WNW.
Can. Scottish, Br. S. S.	Colon	Quebec	49 00 N.	67 17 W.	8th	9 a., 8th	8th	29.46	W	W	NW	SW., 10	W-SW-WNW.
Louisiana, Am. S. S.	In West Indies		21 38 N.	76 50 W.	9th	7 p., 9th	10th	29.50	N	—, 9	NW	—, 11	
Noorderdijk, Du. S. S.	Rotterdam	Galveston	29 16 N.	67 50 W.	11th	6 p., 11th	12th	29.66	NE	NNE., 9	NNE	NNE., 9	Steady NNE.
Bayano, Br. S. S.	Avonmouth	Bermuda	32 13 N.	63 56 W.	10th	2 p., 13th	13th	29.71	ESE	NE., 7	E	N., 10	N-NE-E.
Verentia, Br. S. S.	London	Montreal	50 41 N.	31 00 W.	12th	8 a., 12th	13th	28.33	S	S	NW	—, 12	S-W-NW-N.
Regina, Br. S. S.	Montreal	Liverpool	55 56 N.	32 14 W.	11th	4 a., 13th	13th	29.10	WNW	NW., 7	SW	NW., 10	NW-W-SW.
Adriatic, Br. S. S.	New York	Liverpool	48 53 N.	32 40 W.	12th	6 a., 12th	12th	28.70	SSE	NW., 9	NW	—, 12	SSE-NE-NW.
Wieldrecht, Du. S. S.	Pensacola	London	48 30 N.	28 50 W.	12th	11 a., 12th	12th	29.08	SW	SW., 12	NNW	SW., 12	SW-NW.
Independence Hall, Am. S. S.	Havre	New York	45 45 N.	40 35 W.	14th	2 p., 15th	16th	29.30	WSW	S., 11	NNW	S., 11	S-SW.
Cockaponset, Am. S. S.	Galveston	Havre	48 05 N.	31 32 W.	15th	4 a., 16th	16th	29.56	SSW	S., 10	S	S., 11	
River Delaware, Br. S. S.	Gibraltar	New York	34 22 N.	65 10 W.	16th	1 a., 16th	19th	29.62	S	S., 6	NNW	SW., 9	S-W-NNW.
Stanley, Am. S. S.	London	New York	37 30 N.	65 30 W.	17th	2 a., 17th	17th	29.72	NW	NW., 10	NW	NW., 10	Steady NW.
Pres. Harding, Am. S. S.	Bremhaven	New York	44 12 N.	47 56 W.	17th	4 p., 17th	18th	29.33	SSE	S., 10	WSW	S., 10	S-SW.
Rathlin Head, Br. S. S.	Calcutta	Hamburg	35 53 N.	1 25 W.	19th	Noon, 19th	21st	29.98	NE	ENE., 9	ENE	ENE., 9	Steady ENE.
Texas, Dan. S. S.	Galveston	Aalborg, Denmark.	40 40 N.	51 10 W.	20th	4 a., 20th	21st	29.63	NNE	NE., 9	N	—, 10	
W. C. Teagle, Am. S. S.	New York	Tampico	28 22 N.	92 20 W.	20th	Mid., 20th	21st	29.81	N	N., 6	N	N., 8	Steady N.
Santa Veronica, Am. S. S.	Mobile	New York	32 28 N.	77 50 W.	22d	1 a., 22d	22d	29.39	SE	SW.,	NW	SW., 10	SW-NW.
Steel Ranger, Am. S. S.	Port Said	Boston	39 12 N.	65 20 W.	22d	8 a., 23d	23d	29.38	SE	SE., 10	NW	SE., 10	SE-W-NW.
Amasia, Germ. S. S.	Colon	Jacksonville	19 08 N.	85 00 W.	25th	6 p., 25th	26th	29.94	NNE	N.,	NE	—, 9	
Westerdijk, Du. S. S.	Rotterdam	New York	48 32 N.	30 37 W.	24th	4 p., 24th	25th	29.74	NNW	NNW., 7	N	N., 9	NNW-N.
Crofton Hall, Am. S. S.	London	New York	42 45 N.	15 00 W.	24th	10 p., 25th	27th	29.25	SSW	N.,	WSW	N., 9	N-WNW-NW.
Novian, Br. S. S.	London	Boston	49 47 N.	15 59 W.	26th	1:30 a., 26th	26th	29.22	WNW	NE., 12	NE	NE., 12	WNW-ENE-NE.
Rochambeau, Fr. S. S.	Havre	New York	48 30 N.	40 30 W.	27th	3 p., 27th	28th	29.36	W	WNW.,	WNW	—, 12	WSW-W.
West Cheswald, Am. S. S.	London	New Orleans	33 45 N.	52 30 W.	25th	2 a., 25th	25th	29.91	NW	NNW.,	NE	NNW., 8	NW-NNW.
Blair, Am. S. S.	Alexandria	Boston	28 52 N.	69 04 W.	29th	4 p., 29th	30th	29.59	SW	SW., 7		NW., 12	SW-WSW.
Zarembo, Am. S. S.	Bordeaux	New York	35 50 N.	65 10 W.	29th	9 p., 29th	Dec. 1	29.60	W	W., 9	NW	W., 9	WNW-NW.
North Pacific Ocean													
Broad Arrow, Am. S. S.	Shanghai	San Pedro	39 29 N.	165 10 E.	Oct. 30	Noon, 3d	Nov. 4	29.13	WNW	SE., 10	WSW	SE., 10	Variable.
Pres. McKinley, Am. S. S.	Victoria	Yokohama	50 26 N.	177 21 E.	Oct. 31	12 mid	Nov. 1	29.55	N	N., 6	NNW	N., 8	N-NNW.
F. J. Luckenbach, Am. S S.	San Pedro	Galveston	14 50 N.	97 19 W.	Nov. 2	3p., 2d	3d	29.82	E	E., 4	NE	NE., 8	E-ENE
Silvercedar, Br. S. S.	do	Yokohama	34 48 N.	159 50 E.	2d	4a., 3d	3d	29.28	S	S., 9	W	S., 9	S-SW-W.
Do	do	do	34 40 N.	151 45 E.	5th	11p., 5th	6th	29.75	S	S., 10	W	S., 10	S-W-NNW.
Tejon, Am. S. S.	do	Jebisu, Japan.	32 44 N.	157 53 E.	2d	2a., 3d	3d	29.41	SE	S., 10	WNW	S., 10	S-WNW.
Do	do	do	36 47 N.	151 10 E.	5th	8 p.	5th	29.76	SSW	SSW., 10	W	SSW., 10	SSW-NW.
Do	do	do	40 10 N.	139 E.	9th	8 p.	9th	29.44	SSW	SSW., 9	SW	SSW., 9	SSW-SW.
Empress of Asia, Br. S. S.	Yokohama	Vancouver	40 47 N.	151 51 E.	3d	8a., 3d	4th	29.11	NW	NW., 10	W	W., 11	NW-WNW.
Harold Dollar, Br. S. S.	Shanghai	San Francisco.	41 50 N.	153 50 E.	3d	4a., 3d	4th	27.84	S	SE., 12	W	SE., 12	S-SE-SW-NW.
Iyo Maru, Jap. S. S.	Yokohama	Victoria	46 N.	167 E.	3d	8 p., 3d	4th	28.18	SE	E., 7	W	—, 10	NNW-WSW.
Meiko Maru, Jap. S. S.	Meike, Japan.	Portland, Oreg.	48 27 N.	132 13 W.	4th	Noon, 6th	7th	29.30	W	NW., 8	NW	NW., 8	NW.
Pres. Garfield, Am. S. S.	Honolulu	Kobe	33 36 N.	155 27 E.	10th	—, 10th	12th	29.64	SW	SW	W	SW., 8	SW-W.
West Jessup, Am. S. S.	Portland	Nagoya, Japan.	42 56 N.	147 40 E.	10th	1a., 11th	12th	28.60	ESE	SSW., 1	WNW	WNW., 11	W-NW.
West Niger, Am. S. S.	Davao, P. I.	Portland	42 43 N.	714 33 E.	13th	6a., 13th	14th	28.97	WSW	WSW., 7	WNW	WNW., 9	WSW-N.
Niagara, Br. S. S.	Sydney, Aus.	Vancouver	47 30 N.	126 29 W.	13th	2 p.	13th	29.90	SE	SE., 9	SE	SE., 10	Steady.
Yayoi Maru, Jap. S. S.	Wakamatsu, Japan.	Astoria	50 N.	146 40 W.	15th	Noon, 15th	18th	28.68	SE	S., 6	ESE	WNW., 10	
Tascalusa, Br. S. S.	Hongkong	San Francisco.	45 22 N.	148 15 W.	15th	3 p., 16th	17th	28.70	SSE	ENE., 7	SW	W , 10	Variable
Can Importer, Br. S. S.	Brisbane	Vancouver	48 N.	126 30 W.	17th	8 p., 17th	18th	29.30	SE	SE., 9	S	—, 10	SE-S.
Hakata Maru, Jap. S. S.	Yokohama	Seattle	49 21 N	129 50 W.	19th	11a., 19th	20th	29.35	SE	SE., 9	SW	—, 10	SE-SW
Kaga Maru, Jap. S. S	Victoria	Yokohama	39 45 N.	147 E.	21st	Noon, 21st	22d	29.35	SE	S., 7	W	W., 9	
George Washington, Nor. M. S.	Balboa	San Pedro	16 16 N.	94 45 W.	22d	4 p.	22d	29.80	NNW	N., 9	N	N., 9	
Pres. Madison, Am. S. S.	Yokohama	Seattle	44 20 N.	160 E.	22d	6a., 22d	24th	28.44	SW	W., 6	W	W., 9	SW-W.
Africa Maru, Jap. S. S	do	Victoria	48 36 N.	179 16 E.	23d	4a., 25th	25th	28.83	WSW	NW., 9	NW	W., 9	
Tejon, Am. S. S.	Jebisu, Japan.	San Pedro	41 23 N.	153 38 W.	25th	3 p.	25th	28.81	S	S	SSW	—, 9	S-WSW.
West Himrod, Am. S. S.	Kobe	Seattle	50 10 N.	152 40 W.	25th	2a., 26th	26th	28.04		SW., 10		SW., 10	
Can. Prospector, Br. S. S.	Vancouver	Boston	13 49 N.	95 44 W.	28th	3a.	28th	29.91	E	NNE., 8	N	NNE., 8	E-NE-N.
Edmore, Am. S. S.	Cebu, P. I.	Seattle	47 03 N.	175 20 E.	29th	2a.	29th	28.92	E	ENE., 9	NW	ENE., 9	

NORTH PACIFIC OCEAN

By WILLIS EDWIN HURD

Like the preceding month, November was characterized by much cloudy sky, though low percentage of fog, over the northern part of the ocean. Fog was observed, however, over practically the entire area in upper latitudes. Between 45° and 55° N. and 150° and 170° W., it was reported on the 10th to 14th, inclusive. Between 170° W. and the Japanese coast scattered fog occurred on nearly all dates from the 1st to the 10th, but it most frequently appeared in the American coast region between 25° and 50° N. where, taking the belt as a whole, it was recorded on 21 days. The southernmost observation of fog was on the 7th, in 13° 40′ N., 94° 23′ W. Snow, sleet, and hail squalls were reported on a few dates along the northern routes.

At Honolulu northeast winds prevailed. The average velocity there was 8.6 miles an hour, which is somewhat less than the normal. But the maximum velocity was at the rate of 51 miles an hour, on the 21st, which is the highest ever recorded in November, and the third highest ever recorded in any month. This occurred during a northeast to east gale which lasted for more than 48 hours from the 20th to the 22d, while Honolulu was on the southern slope of the North Pacific HIGH at the time of its greatest activity. The highest temperature of the year at Honolulu, 85°, occurred on November 6.

Little weather of a disturbing nature was experienced by vessels plying between San Francisco and Panama, except for gales of forces 8 and 9 which roughened the sea on several dates over and south of the Gulf of Tehuantepec. There were reports of less than the usual amount of rain along this route. In fact, precipitation was less than normal along the entire west coast of the United States as well as at Honolulu. Farther north along the coast precipitation increased and was above normal at Juneau, Alaska.

The few tropical disturbances in the Far East during the month are discussed elsewhere in this issue of the REVIEW by the Rev. José Coronas, S. J., of the Manila Observatory. Our vessel reports, in addition, indicate rough weather between Hongkong and Manila near the middle of the month. High pressure lay over China during most of the period, but several cyclones issued from Manchuria.

The great anticyclone lying normally between Hawaii and northern California was unsteady in prevalence and extent, occasionally dominating most of the eastern part of the ocean, but quite largely being pushed aside or divided by the southward pulsations of the Aleutian cyclone.

Low pressure did not enter the Aleutian area until November 10, although for several days previously cyclonic conditions had prevailed over the eastern part of the Gulf of Alaska, during a part of which time the weather was unusually rough for the season down the Alaskan southeast coast. The maximum wind velocity at Juneau was at the rate of 54 miles an hour from the east, on the 9th. After the 10th the semipermanent LOW settled with considerable intensity over the central Aleutians, whence, after the middle of the month, it fluctuated back and forth over a considerable region. On the 22d a gradient of 1 inch in pressure lay between Dutch Harbor and Kodiak, the extreme readings being: Dutch Harbor, 29.62; Kodiak, 28.62. Several cyclonic storms of Asiatic source moved into the Aleutian LOW during the last two decades.

If we consider the three island stations of Dutch Harbor, Midway Island, and Honolulu as indicative of the pressure alignment up and down the central North Pacific Ocean, it is found that fairly normal conditions for the month prevailed, except perhaps at Dutch Harbor, where the average p. m. pressure (29 days) was 29.46, or 0.13 inch below the normal. Here, however, the pressure is likely to be very eccentric, especially during the colder months. After the 10th the readings were almost continuously low. There was a wide barometric range, the highest reading being 30.62, on the 4th; the lowest, 28.14, on the 26th. At Midway Island subnormal pressures occurred except on nine days during the latter half of the month. The p. m. mean was 30.06, or 0.05 inch below normal. The highest reading was 30.40, on the 19th; the lowest, 29.90, on the 3d and 9th. The daily departures at Honolulu were not great, and the average pressure, 30.05, was only 0.03 above the normal, while the extremes were 30.16, on the 20th, and 29.90, on the 10th.

The adjoined table of gales and storms indicates pretty thoroughly the wind and pressure conditions accompanying the LOW formations of November. Gales of forces 9 and 10 were common to both east and west longitudes, in the latter especially north of the 40th parallel. There seems to have been a zone of quiet up and down the ocean between 160° and 170° W., since no gales were reported from it. Between 175° W. and 165° E. and 45° and 50° N. steamships encountered the most frequent gales—on at least 50 per cent of the days. But the severest storm winds of the month were the product of cyclones leaving northern Japan during the early half. On the 3d the British steamships *Empress of Asia* and *Harold Dollar* experienced storm to hurricane winds near 41° N., 153° E. The *Harold Dollar*, while the southeast hurricane was in progress, reported the lowest pressure of the month—27.84 inches. As the vessel's barometer went out of commission shortly after this reading was made, there may be some doubt as to its accuracy. On the 11th severe weather occurred west of that of the 3d, at which time the American steamship *West Jessup* reported a westerly gale of force 11, pressure 28.60, southeast of Hokkaido.

Waterspouts.—The American steamship *President Garfield* reported the following:

Nov. 3. 4 p. m. Lat. 25° 55′ N., long. 166° 58′ W. Wind SW., force 4, sea rough, temperature of the air 74°, cloudiness 7 (St. Cu.), barometer 29.76.

Observed five waterspouts within an area of 4 miles. Four of them were low, the tops ending in a mushroom which could be seen very plainly; but one reached to the clouds, also ending in a mushroom top, the whole of which was darker than the surrounding clouds. They lasted for about 30 minutes, moving eastward and rotating in a clockwise direction. The four low ones dropped. The high one had a very decided curve in it a little above the center, the upper part ascending and the lower part dropping. At the end it seemed to fade away.

The United States Army transport *Thomas* observed a small waterspout on the 29th in 34° 15′ N., 148° 50′ E.

TWO TYPHOONS IN THE PHILIPPINES DURING NOVEMBER, 1924

By REV. JOSÉ CORONAS, S. J.

[Weather Bureau, Manila, P. I.]

The first of these typhoons seems to have formed on the 20th to 21st over the Pacific to the north of Yap, near 139° longitude E. and 13° latitude N. The U. S. S. *Chaumont* experienced very bad weather with strong winds and even gales from the south quadrants on her way from Guam to the Philippines. According to observations made on board of this steamer the typhoon, after moving west for more than one day, took a northerly

direction on the night of the 22d and morning of the 23d while decreasing its rate of progress. Then in the afternoon of the 23d and on the 24th it remained almost stationary near 130° longitude E. and 16° latitude N. On the 25th it began to move westward and so rapidly that from 2 p. m. of the 25th to 6 a. m. of the 26th its rate of progress was about 26 miles per hour, a very extraordinary velocity for our latitude. This was the more remarkable because while crossing Luzon with such a velocity it was only a shallow depression of no great importance.

The center of the depression passed about 80 or 90 miles to the north of Manila in the early morning of the 26th moving west. Once in the China Sea it increased again in intensity and took a southwesterly direction, until it probably filled up on the 29th not far from 110° longitude E. and 8° latitude N.

The second typhoon of the month was shown for the first time by our weather maps at 6 a. m. of the 28th near 132° or 133° longitude E. and 10° latitude N. It moved west by north and traversed the Visayan Islands on the 29th through southern Samar, northern Leyte and northern Panay. After passing between Mindoro and Cuyo in the early morning of the 30th it inclined somewhat to the north, and at the time we are writing these notes (December 2), the center is still over the China Sea, about 300 miles to the west of Luzon and to the east-southeast of the Paracels, moving very slowly and possibly with a tendency to incline still more to the north.

We may add that at the end of the preceding month of October a typhoon was noticed moving northward about 150 or 200 miles to the east of Luzon, and that it recurved northeastward on the 31st of October to the east of Balintang and Bashi Channels. The position of the center at 6 a. m. of October 31 to November 2 was as follows:

October 31, 6 a. m., 20° 50′ latitude N., 125° 45′ longitude E.
November 1, 6 a. m., 25° 50′ latitude N., 131° 10′ longitude E.
November 2, 6 a. m., 35° latitude N., 145° longitude E.

DETAILS OF THE WEATHER IN THE UNITED STATES

GENERAL CONDITIONS

By ALFRED J. HENRY

The outstanding feature of the month was the establishment on the 13th of anticlyconic conditions over the Great Basin and the continuance of these conditions with but little change until the close of the month.

Another way of expressing this fact is to say that on the 13th a pronounced flow of cold polar air descended from the Canadian Northwest upon the northern Rockies and the Great Basin. This mass of cold air must have extended upward to a considerable altitude, since instead of skirting the eastern slope of the mountains it overrode them and settled over the Great Basin as before stated. From that region as a pivoted point detached masses of cold air moved southeastward on various subsequent dates overflowing the Gulf States and the lower Mississippi Valley, thus preventing the development in or the movement of cyclonic systems through that region.

This pressure distribution—high centered over the Great Basin with high though diminishing pressure thence southeastward—was effective in preventing precipitation in southern and central California and particularly in the Gulf States and lower Mississippi Valley.

The month as a whole must be classed as fairly warm and dry. The usual details follow.

CYCLONES AND ANTICYCLONES

By W. P. DAY

There was a marked increase of weather activity during November as compared with October, at least over the United States. This is shown in part by the charting of 19 well-developed LOWS against 14 during the preceding month and 15 HIGHS compared with 11. There were no HIGHS of the Hudson Bay type, which with others were effective during October in holding up and deflecting the normal movement of LOWS. The plateau HIGH was well developed during the latter half of the month and the LOWS made a corresponding shift from the North Pacific to the Alberta type or to developments east of the Rockies

FREE-AIR SUMMARY

By V. E. JAKL

In the upper-air averages for the month there were no important departures in any of the weather elements, except that all stations showed a decidedly stronger wind movement than usual throughout the vertical extent of the observations. (See Tables 1 and 2.) Temperature departures for all altitudes observed over the region represented by kite observations were substantially the same as those for the surface (see Chart III), the departures being as a rule quite uniform with altitude and generally positive and of small value. At Due West and Royal Center the temperature at all levels was normal to slightly below normal, as distinguished from the higher than normal temperature at all the other stations. The tables of average relative humidity and vapor pressure for the different stations show no important features, except as they indicate a general slightly drier condition aloft than is normal for the month.

Winds were practically normal in direction for all levels, the upper air resultants for the month determined from kite and pilot balloon observations over the middle and eastern portions of the country showing a general westerly drift. Above 1,000 meters there was a slight but general and definite northerly component to the winds over most stations, while in the levels embraced by the first thousand meters above sea level an average movement from about southwest was prevalent. This general westerly tendency of the winds probably extended to the Pacific coast, as pilot balloon observations at San Francisco gave resultant winds from approximately northwest to a considerable altitude.

Except over Key West and San Juan, winds aloft having an easterly component were almost entirely absent, one or two observations each of easterly winds at high altitudes being reported from Groesbeck, Memphis, and San Francisco. Over Key West and San Juan, the resultants of pilot-balloon observations showed deep northeasterly and southeasterly winds respectively.

The principal characteristic of the wind records is the frequency with which strong upper-air winds occurred,

especially from directions between north and west. Velocities varying from 30 m. p. s. to 50 m. p. s. were reported on various dates from all portions of the country covered by aerological observations, in some instances the high winds being observed as low as 1,000 meters altitude, and in others above 10,000 meters. The effect of these strong winds on the averages is well shown in the excess of the resultant winds over the normal in Table 2.

The most pronounced instances of strong northwesterly winds aloft of more or less general occurrence over the eastern portion of the country, are noted in the last decade of the month, during which period vigorous extensive LOWS passing eastward and southeastward, were a dominant feature of pressure conditions over middle-northern and eastern sections. This relation between winds aloft and cyclonic movement is apparent in the conditions for the whole month, the average strong drift in the upper air from west-northwest being undoubtedly associated with the prevalent rapid movement of LOWS across the country in the same general direction. A possible connection may also be inferred between this characteristic of the winds during the month and the lack of LOWS moving from southwest, and consequent deficiency in frequency and amount of precipitation over middle-western sections.

The effect of the excess strength of the northwesterly winds aloft on the average temperature of the northwestern stations was to raise the temperature, as compared with the normal, rather than to depress it, as would usually be expected. This appears to have been due to the relatively warm northwesterly winds aloft observed in advance and in the rear of LOWS soon after their first appearance in the Northwest. An example of the latter case is given in the records of Drexel and Ellendale on the 3d, when these stations were in the rear of a well defined LOW that appeared the day before over the North Pacific coast. The upper-air records on this date show definitely higher temperatures at both stations in west to northwest winds than 24 hours previously in southerly winds at corresponding levels, when the stations were in the rear of a HIGH.

A pronounced instance of recovery of temperature in a northwesterly wind aloft preceding a LOW that had its origin over the Pacific is shown in the records of Ellendale and Drexel on the 29th. Low temperature for the season to the upper limit of observation on the 28th gave way on the 29th to a rapid rise in temperature in the upper levels in a northwest wind preceding a LOW approaching from the northwest. In the lower levels the wind was from a southerly direction and the temperature still low. This is a type of vertical temperature distribution occasionally observed in western sections in the colder seasons, when after a cold HIGH has passed the station, the south winds at low altitudes in its rear are still cold, while an approaching LOW from the northwest brings much warmer air in a northwesterly drift aloft. An extension of this warming up process to lower levels attending the passage of the LOW sometimes causes a condition to supervene, similar to that cited on the 3d.

In the following table giving temperatures at Drexel and Ellendale on the 28th and 29th, a comparison is made with temperatures on the same days at Due West, where at a number of upper levels temperatures below all previous records for the time of year were recorded, due to the transportation toward the southeast of cold air that lay to the northward on the 28th. This table illustrates some of the peculiar horizontal temperature gradients frequently revealed in aerological records made in the colder season. It will be noted that there was an opposite temperature gradient, at the surface and aloft in a northwest-southeast direction between Ellendale and Due West.

Altitude m. s. l., meters	Ellendale (444 meters)		Drexel (396 meters)		Due West (217 meters)	
	28th	29th	28th	29th	28th	29th
Surface	−13.5 NNW.	−5.5 SSW.	−6.6 WSW.	−9.5 S.	0.7 SW.	1.2 WNW.
500	−13.8 NNW.	−5.7 SSW.	−6.6 W.	−8.7 SSW.	3.4 WSW.	0.6 NW.
750	−15.3 NNW.	−6.1 SW.	−6.6 NW.	−6.8 SW.	5.5 W.	−0.7 NW.
1,000	−16.8 NNW.	−1.8 WSW.	−7.0 NNW.	−4.4 WNW.	4.4 WSW.	−2.2 WNW.
1,250	−18.3 NNW.	2.5 W.	−8.9 NNW.	−3.1 NW.	3.2 WSW.	−3.8 WNW.
1,500	−14.2 NNW.	6.8 WNW.	−10.7 NNW.	−2.4 NW.	2.0 WSW.	−4.4 WNW.
2,000	−13.0 NNW.	4.0 WNW.	−15.5 NW.	−1.0 NW.	−0.5 W.	−5.6 W.
2,500	−15.3 NNW.	0.2 NW.	−13.1 NW.	−1.7 NW.		−7.9 W.

The kite observation at Broken Arrow on the 13th, shown in the following table, is a good illustration of the vertical arrangement of wind directions attending the passage of a wind shift line over the station. The surface winds veered abruptly from southwest to north-northwest, accompanied by a drop of about 16° C. in temperature in three hours, while the winds aloft continued from a southwesterly direction till the end of the observation. No considerable precipitation occurred at Broken Arrow till the follow day, but a heavy shower occurred in connection with the wind shift line 15 miles west-northwest of the station.

Meteorological conditions over Broken Arrow, Okla., on November 13, 1924:

Time, p. m.	Surface wind direction	Altitude m. s. l. (m.)	Temperature (° C.)	Relative humidity, per cent	Wind direction
12.28	SW	3,518	0.8	82	SW.
12.41	NNW	2,669	4.8	87	SSW.
12.46	NW	2,037	8.0	88	SSW.
1.06	NNW	1,003	15.3	74	SW.
1.12	NNW	619	15.4	94	NW.
1.19	NNW	[1] 233	17.1	97	NNW.

[1] Surface.

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during November, 1924*

TEMPERATURE (°C.)

Altitude, m. s. l. (m.)	Broken Arrow, Okla. (233m.)		Drexel, Nebr. (396m.)		Due West, S. C. (217m.)		Ellendale, N. Dak. (444m.)		Groesbeck, Tex. (141m.)		Royal Center, Ind. (225m.)	
	Mean	Departure from 7-yr. mean	Mean	Departure from 10-yr. mean	Mean	Departure from 4-yr. mean	Mean	Departure from 7-yr. mean	Mean	Departure from 7-yr. mean	Mean	Departure from 7-yr. mean
Surface	12.6	+2.4	3.8	+0.1	11.1	−0.4	−0.9	+1.0	13.4	+0.4	4.9	0.0
250	12.5	+2.4			11.0	−0.3			13.4	+0.6	4.7	0.0
500	11.3	+2.2	3.8	+0.2	10.0	−0.3	−1.2	+0.7	13.4	+1.2	3.2	0.0
750	10.1	+1.8	3.5	+0.2	9.0	−0.2	−1.6	+0.2	12.4	+0.9	2.3	0.0
1,000	9.0	+1.3	3.3	+0.1	7.9	−0.5	−1.6	−0.1	11.3	+0.4	1.2	−0.4
1,250	8.2	+1.1	3.3	+0.3	7.0	−0.8	−1.3	+0.2	10.1	0.0	0.1	−1.0
1,500	7.4	+1.0	2.7	+0.2	6.0	−0.6	−1.4	+0.4	8.8	−0.5	−0.2	−0.8
2,000	5.6	+1.1	1.1	+0.3	4.2	−1.1	−2.6	+0.7	6.9	−0.4	−2.6	−1.5
2,500	3.5	+1.1	−1.1	+0.4	3.4	0.0	−4.9	+0.6	6.7	+1.4	−4.6	−1.7
3,000	1.4	+1.3	−3.6	+0.5	0.7	−0.2	−7.5	+0.5	4.4	+1.5	−7.0	−1.9
3,500	−0.7	+1.6	−6.2	+0.6	−2.2	−0.3	−10.5	+0.3	1.5	+1.4	−9.1	−2.0
4,000	−3.4	+1.4	−8.7	+0.8	−5.9	−1.1	−13.3	+0.4	−0.9	+1.8	−12.5	−2.4
4,500	−6.3	+1.1	−11.5	+0.7	−9.3	−0.7			−3.7	+2.0		
5,000	−9.6	+0.6	−14.3	+0.8	−12.7	−0.7						

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during November, 1924*—Continued

RELATIVE HUMIDITY (%)

Altitude m. s. l. (m.)	Broken Arrow, Okla. (233m.) Mean	Departure from 7-yr. mean	Drexel, Nebr. (396m.) Mean	Departure from 10-yr. mean	Due West, S. C. (217m.) Mean	Departure from 4-yr. mean	Ellendale, N. Dak. (444m.) Mean	Departure from 7-yr. mean	Groesbeck, Tex. (141m.) Mean	Departure from 7-yr. mean	Royal Center, Ind. (225m.) Mean	Departure from 7-yr. mean
Surface	55	−11	64	−7	70	+2	68	−11	74	−1	67	−6
250	55	−11			68	+1			71	−1	67	−6
500	52	−10	61	−7	60	−3	67	−10	64	−3	67	−5
750	51	−9	58	−5	57	−3	66	−6	62	−1	66	−3
1,000	50	−8	57	−1	57	−1	64	−3	60	0	66	0
1,250	48	−7	55	0	53	−3	61	−2	57	0	64	+2
1,500	46	−6	53	0	50	−4	58	−1	56	+2	59	+1
2,000	41	−7	48	−2	46	−2	52	−3	49	0	61	+7
2,500	38	−8	46	−4	33	−10	52	−3	25	−18	56	+6
3,000	33	−12	46	−5	32	−9	53	−2	20	−19	54	+6
3,500	27	−14	49	−3	30	−11	53	−3	19	−19	49	+3
4,000	20	−16	52	0	28	−13	56	−2	17	−18	49	+6
4,500	20	−13	52	+2	28	−17			16	−18		
5,000	19	−15	52	+4	28	−17						

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during November, 1924*—Continued

VAPOR PRESSURE (*mb.*)

Altitude m. s. l. (m.)	Broken Arrow, Okla. (233m.) Mean	Departure from 7-yr. mean	Drexel, Nebr. (396m.) Mean	Departure from 10-yr. mean	Due West, S. C. (217m.) Mean	Departure from 4-yr. mean	Ellendale, N. Dak. (444m.) Mean	Departure from 7-yr. mean	Groesbeck, Tex. (141m.) Mean	Departure from 7-yr. mean	Royal Center, Ind. (225m.) Mean	Departure from 7-yr. mean
Surface	8.07	−0.12	5.18	−0.58	9.74	+0.36	3.84	−0.62	12.28	+0.47	6.14	−0.46
250	8.02	−0.10			9.53	+0.31			11.79	+0.42	6.07	−0.45
500	7.33	−0.02	5.00	−0.51	8.05	−0.12	3.71	−0.67	10.62	+0.37	5.38	−0.43
750	6.62	−0.10	4.56	−0.42	7.13	−0.18	3.47	−0.59	9.66	+0.44	4.89	−0.34
1,000	6.02	−0.20	4.35	−0.21	6.44	−0.26	3.30	−0.46	8.59	+0.24	4.40	−0.25
1,250	5.46	−0.22	4.14	−0.10	5.59	−0.43	3.18	−0.31	7.34	−0.07	3.92	−0.21
1,500	4.95	−0.15	3.83	−0.09	4.72	−0.68	3.03	−0.20	6.43	−0.17	3.55	−0.13
2,000	3.79	−0.27	3.07	−0.16	3.57	−0.57	2.55	−0.18	4.78	−0.29	3.17	+0.16
2,500	2.93	−0.30	2.61	−0.10	1.98	−1.29	2.12	−0.20	2.10	−1.67	2.76	+0.37
3,000	2.05	−0.57	2.19	−0.09	1.31	−1.31	1.75	−0.17	1.15	−1.59	2.41	+0.29
3,500	1.35	−0.60	1.88	0.00	0.61	−1.64	1.35	−0.21	.89	−1.24	1.90	+0.19
4,000	0.80	−0.52	1.61	+0.07	0.29	−1.51	1.01	−0.29	.65	−0.86	1.56	+0.72
4,500	0.68	−0.25	1.24	+0.06	0.19	−1.44			.52	−0.50		
5,000	0.53	−0.23	0.96	+0.09	0.11	−1.44						

TABLE 2.—*Free-air resultant winds (m. p. s.) during November, 1924*

Altitude, m. s. l. (m.)	Broken Arrow, Okla. (233m.) Mean		7-year mean		Drexel, Nebr. (396m.) Mean		10-year mean		Due West, S. C. (217m.) Mean		4-year mean	
	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.
Surface	S. 54° W.	3.4	S. 48° W.	1.3	S. 80° W.	2.4	S. 82° W.	1.5	S. 67° W.	0.8	N.73°W.	0.7
250	S. 55° W.	3.4	S. 45° W.	1.4					S. 63° W.	1.2	N.73°W.	0.7
500	S. 58° W.	3.9	S. 32° W.	2.4	S. 84° W.	3.2	S. 84° W.	2.1	S. 69° W.	3.4	N.86°W.	1.5
750	S. 61° W.	4.7	S. 38° W.	3.1	S. 86° W.	5.2	W.	3.7	S. 87° W.	3.7	N.81°W.	2.1
1,000	S. 66° W.	5.2	S. 50° W.	3.8	N.88°W.	7.5	N.89°W.	5.1	S. 83° W.	4.1	N.87°W.	2.7
1,250	S. 75° W.	6.2	S. 58° W.	4.6	N.82°W.	9.2	N.86°W.	6.1	S. 85° W.	5.5	N.85°W.	4.0
1,500	S. 77° W.	8.1	S. 66° W.	5.3	N.82°W.	10.0	N.86°W.	7.1	S. 85° W.	6.8	N.88°W.	5.4
2,000	S. 86° W.	9.5	S. 74° W.	6.7	N.80°W.	11.6	N.82°W.	8.2	S. 74° W.	9.5	S. 88° W.	7.4
2,500	S. 85° W.	9.6	S. 79° W.	7.3	N.79°W.	13.8	N.79°W.	10.0	S. 66° W.	9.8	S. 86° W.	8.9
3,000	S. 80° W.	9.5	S. 7. ° W.	8.7	N.82°W.	15.1	N.79°W.	11.2	S. 40° W.	8.6	S. 89° W.	10.0
3,500	S. 74° W.	11.6	S. 78° W.	9.3	N.79°W.	17.3	N.76°W.	12.1	S. 26° W.	8.6	S. 87° W.	11.9
4,000	S. 84° W.	12.1	S. 82° W.	11.0	N.85°W.	19.1	N.81°W.	13.6	S. 45° W.	14.0	W.	13.9
4,500	N.60°W.	10.1	N.85°W.	9.6	N.87°W.	19.6	N.85°W.	14.2	S. 45° W.	14.0	N.87°W.	15.4
5,000	N.64°W.	10.7	S. 75° W.	11.3	N.77°W.	17.3	N.79°W.	13.5	S. 45° W.	14.0	N.85°W.	14.7

Altitude, m. s. l. (m.)	Ellendale, N. Dak. (444m.) Mean		7-year mean		Groesbeck, Tex. (141m.) Mean		7-year mean		Royal Center, Ind. (225 m.) Mean		7-year mean	
	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.
Surface	N.57°W.	3.6	N.52°W.	2.3	S. 2° E.	1.4	N. 64° E.	0.2	S. 61° W.	3.8	S. 46° W.	1.9
250					S. 4° W.	2.8	S. 68° W.	0.5	S. 57° W.	4.2	S. 54° W.	2.7
500	N.68°W.	4.1	N.64°W.	2.6	S. 25° W.	5.5	S. 5° E.	1.2	S. 70° W.	6.4	S. 57° W.	4.8
750	N.67°W.	6.1	N.64°W.	4.0	S. 29° W.	6.2	S. 22° W.	1.8	S. 72° W.	9.7	S. 63° W.	6.3
1,000	N.64°W.	7.0	N.67°W.	4.9	S. 39° W.	7.7	S. 43° W.	2.6	S. 83° W.	9.8	S. 70° W.	6.9
1,250	N.72°W.	7.9	N.70°W.	5.9	S. 44° W.	8.2	S. 59° W.	3.1	S. 89° W.	10.3	S. 74° W.	7.7
1,500	N.59°W.	9.6	N.65°W.	7.1	S. 51° W.	7.0	S. 67° W.	3.8	N.81°W.	11.6	S. 78° W.	8.3
2,000	N.64°W.	11.7	N.66°W.	8.7	S. 64° W.	7.7	S. 79° W.	5.2	N.83°W.	13.1	S. 83° W.	9.8
2,500	N.80°W.	11.9	N.68°W.	10.8	S. 64° W.	7.8	S. 85° W.	7.1	N.81°W.	13.9	S. 85° W.	11.4
3,000	N.82°W.	14.0	N.69°W.	12.9	S. 80° W.	9.6	S. 86° W.	8.5	N.84°W.	13.9	N.87°W.	12.7
3,500	N.71°W.	13.3	N.67°W.	13.5	S. 79° W.	11.1	S. 76° W.	10.4	N.84°W.	12.8	N.86°W.	12.3
4,000	N.72°W.	14.8	N.66°W.	13.1	S. 87° W.	6.5	S. 71° W.	8.5	S. 45° W.	19.0	S. 82° W.	10.4
4,500	N.68°W.	19.0	N.61°W.	16.0	S. 77° W.	12.8	S. 67° W.	10.4	S. 45° W.	20.0	S. 79° W.	9.1
5,000												

THE WEATHER ELEMENTS

By P. C. DAY, In Charge of Division

PRESSURE AND WINDS

The anticyclonic conditions persisting so constantly over the Ohio Valley and Northeastern States during October gave way during November, particularly over the more northeastern districts, although the pressure continued high to the southward and anticyclones dominated the weather over the plateau and most other western districts. As a result of this pressure distribution few important cyclones formed over the South or Southwest, and those entering the United States from the Canadian Northwest moved eastward mainly along the northern border.

In the absence of cyclonic disturbances the drought conditions that had set in during October or earlier over many southern and eastern districts continued more or less severe during much of November. The first notable cyclone to give important precipitation to the eastward of the Rocky Mountains moved to the Great Lakes by the morning of the 7th and considerable precipitation occurred in that region in connection therewith, but the storm was quickly dissipated. About the same time, however, some heavy rains occurred over the far Northwest.

Precipitation again occurred in the vicinity of the Great Lakes on the 11th and 12th, due to a shallow depression moving eastward near the northern border. Light precipitation from this depression extended southward into the lower Ohio and middle Mississippi Valleys, and scattered local falls occurred over the Northeastern States. A considerable area of precipitation, though mostly light, extended from the middle and upper Mississippi Valley northeastward and eastward to New England on the 13th and 14th, attending a shallow cyclone that developed over the Ohio Valley on the 13th. About the 18th to 20th material precipitation occurred over the far Northwest, extending into the coast districts of northern California where, in the vicinity of Eureka, the fall was unusually heavy, causing considerable damage to bridges, etc.

The first important precipitation of the month over the Atlantic Coast States occurred in connection with a low-pressure area that moved from North Carolina to New England from the 21st to 23d. Heavy rains occurred in connection with this storm over most of the Atlantic States from Georgia northward, and rains or snows, mostly light, extended westward during the same period into the Ohio Valley and Great Lakes region in connection with a low-pressure area that moved northeastward over the upper Lakes. Light precipitation, mostly snow, occurred on the 24th and 25th over a wide

area from the upper Mississippi Valley eastward and southeastward to the Atlantic coast, and local rains or snows again occurred during the last two or three days of the month from the Great Lakes and Ohio Valley eastward to the coast.

On account of the persistent anticyclonic conditions over the plateau the usual high pressure for that region was materially augmented, and the average pressure was likewise above normal over all southern districts, the ridge of highest averages extending from southern Idaho to the Georgia coast, except that the usual depression on the lee side of the high mountains of Colorado and Wyoming was more pronounced than normal.

Compared with the average pressure for the preceding month there was a sharp fall over all districts from the Ohio Valley and Lake region eastward, and a corresponding rise to the westward and southward.

Due to the general absence of important barometric changes, the pressure gradients were usually small and there were few damaging high winds. The prevailing wind directions conformed mainly to the average pressure distribution, blowing into the low area to northward of the Great Lakes and from the center of high pressure over the Southeastern States and the middle plateau regions, as indicated on Chart VI.

TEMPERATURE

November, like the preceding month, had mainly moderate temperatures, and over the greater part of the country presented few indications of the near approach to winter.

Moderate changes were of rather frequent occurrence over the Great Lakes and nearby areas, and considerable variations were noted in the western mountain districts, but over the Central and Southern States from the Great Plains eastward there were few important breaks in the routine of unusually pleasant weather.

The average temperature for the month as a whole was above normal in all parts of the country save over the far Northwestern States, in extreme southern Florida, and at a few points in the Ohio Valley. Over the Great Plains the monthly averages ranged from 3° to 5° above normal, and in a few localities, particularly in the Southwest, it was the warmest November in 50 years or more.

The important warm periods of the month were mainly during the first few days over the middle and western districts, and generally during the first decade in other portions save over the South Atlantic States, where the highest temperatures were not observed until the 13th and 14th. In a few of the middle Plains States the maximum temperatures during the first few days were among the highest of record for November, and locally in the Lake region the maximum temperatures during the first week were likewise among the highest ever observed in November.

The coldest periods of the month were chiefly near the beginning of the second decade from the Rocky Mountains westward. In the Northeastern States rather severe cold occurred from the 16th to 19th with some record-breaking low readings for November in New York and New England. Over the Gulf and South Atlantic States, the lowest temperatures did not occur until the 25th and 26th, when freezing weather extended to the east Gulf coast and into northern Florida. In the upper Mississippi Valley the lowest temperatures were observed on the 28th and 29th.

PRECIPITATION

The outstanding feature of the weather for November was the widespread and frequently large deficiency in the precipitation. The drought conditions, beginning in October over many eastern and central districts, and even earlier in portions of the lower Mississippi Valley and nearby areas, became more severe as the month advanced, save in local areas, particularly in the Atlantic coast districts where heavy rains from the 21st to 23d gave much relief.

In the middle Gulf States and portions of nearby areas no beneficial precipitation occurred, and many localities had less rain than ever known in November. As October had likewise been a record-breaking month in the matter of least precipitation over much of this area, the combination of two successive months with little or no rain produced drought conditions of the severest type ever known. Much inconvenience resulted from the great lack of water, numerous brush and forest fires occurred and the soil continued too dry for cultivation.

Over many other sections of the country east of the Rocky Mountains the precipitation was also greatly deficient, particularly in New England, the lower Lake region, the Florida Peninsula, and Texas, where as a rule October had likewise been dry.

Considering the precipitation by State units, the averages were everywhere less than normal save for four States in the far Northwest. In California where there had been a long and severe period of drought, the precipitation for the State as a whole was slightly deficient but good rains occurred over most of the State during the first decade though little fell thereafter.

SNOWFALL

Snow occurred over all central and northern sections of the country, though the amounts east of the Rocky Mountains were mainly small except in the Great Lakes region, Ohio Valley, and to the northeastward, where it fell on several dates and the total monthly falls ranged up to 5 inches, with occasional depths of 10 to 15 inches and in a few of the more northern localities to 20 inches.

In the western mountain districts the falls were considerably heavier, and on the whole about what may usually be expected in November.

In California the snowfall was generally light in the Sierra Nevada, and but little remained on the ground at the end of the month. Similar conditions existed in Idaho, New Mexico, Arizona, and Colorado, while in Oregon, Washington, and Nevada there was usually more than the normal fall.

RELATIVE HUMIDITY

There was a general and widespread deficiency in the percentage of relative humidity as compared with the normal, due of course to the unusual lack of rainfall and the excess of dry sunshiny days. The areas of greatest deficiency were mainly between the Rocky and Appalachian Mountains, and in the Gulf States.

SUNSHINE AND CLOUDS

There was abundant sunshine over the greater part of the country from the Rocky Mountains eastward, save over the more northern districts where locally much cloudy weather was the rule. The Southeastern States had an unusual number of sunshiny days, and most of the Southwest had abundant sunshine.

SEVERE LOCAL HAIL AND WIND STORMS, NOVEMBER, 1924

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Madison, Wis.	6	9:53-9:58 p. m.	3,520		$200-$300	Heavy hail	Damage principally to greenhouses	Official, U. S. Weather Bureau.
Walla Walla, Wash., and vicinity.	7					Wind	Some damage to poles, wires and trees in the city and adjacent country.	Do.
Fort Wayne, Ind.	7					High wind	Trees and power lines damaged	Do.
Alta, Iowa	11	7 a. m.				Heavy hail	Very light damage	Do.
Mt. Pleasant, Iowa	11	Noon				do	No appreciable damage	Do.
Keokuk, Iowa	11	12:30 p. m.				Hail	Window glass broken	Do.
Macoupin County, Ill. (northwest part of).	11				15,000	Small tornado	Farm property damaged. One person injured	Do.
Birch Tree, Mo.	11					Tornadic wind	Considerable damage, character of which was not reported.	Do.
Seymour, Mo.	11					Tornadic wind with hail.	Minor damage reported	Do.
New England	17					High wind and cold wave.	Shipping tied up; trees, signs, and awnings damaged.	Do.
North Head, Wash.	20	1:30 a. m.				Thunderstorm	Communication lines out of commission	Do.
Seattle, Wash.	21	10:13-11:15 p. m.				Thunderstorm, rain and hail.	Tower blown down; wires wrecked	Do.
Ward, S. C.	21	10:30 p. m.			5,000	Thunderstorm and wind.	Residences, tenant houses, outbuildings, and timber damaged.	Do.
New England	22					Snow, sleet and wind.	Thousands of dollars damage to telephone, telegraph, and electric systems; many trees destroyed; trains delayed.	Official, U. S. Weather Bureau, Boston Herald (Mass.).
Douglas, Ga.	23					High wind	Lights and a few small houses damaged	Official, U. S. Weather Bureau.

STORMS AND WEATHER WARNINGS

WASHINGTON FORECAST DISTRICT

On the morning of the 2d a disturbance of moderate intensity was over the St. Lawrence Valley and fresh to strong west and northwest winds were forecast for the New England coast and strong winds attaining moderate gale force at times occurred during the ensuing 24 hours.

On the evening of the 7th, with a disturbance over the upper St. Lawrence Valley, southwest storm warnings were ordered for the New England coast and strong winds and moderate gales occurred substantially as indicated.

On the evening of the 8th a tropical disturbance of slight intensity was near Santiago, Cuba. After moving slowly northward to about latitude 22° and longitude 76° by the evening of the 9th, its progress was checked by a high-pressure area that covered the Atlantic States. During the next 36 hours it advanced eastward to a position just west of Turks Island. Thus far its progress had been slow, but beginning with the morning of the 11th its rate of movement increased as it passed north-northeastward to a position about 200 miles southeast of Bermuda by the evening of the 13th. Its subsequent course was apparently northeastward. The disturbance was of small diameter and considerable intensity near the center. On the evening of the 10th the U. S. S. *Concord* in latitude 21° 35′ N., and longitude 74° 15′ W. passed near the storm center, reporting a pressure reading of 29.40 inches and a wind velocity of 82 miles per hour.

Beginning with the evening of the 8th advices concerning the location, probable intensity and direction of movement of this disturbance were issued twice daily.

In connection with a disturbance of increasing intensity which was over Nova Scotia on the evening of the 16th, storm warnings were ordered from Nantucket to Eastport and warnings of strong northwest winds off the coast were disseminated by radio. This offshore blow continued into the night of the 17th.

In the trough of the disturbance that was over Lake Michigan on the morning of the 21st, a secondary depression developed over the east Gulf States. During the next 24 hours it had advanced to the North Carolina coast with greatly increased intensity and by the morning of the 24th it was over the lower St. Lawrence, having caused gales along the entire Atlantic seaboard, warnings of which were ordered well in advance.

On the morning of the 27th storm warnings were ordered for the Atlantic coast from Delaware Breakwater to Nantucket, but due to the decrease in intensity of the low-pressure area, which had moved from Ontario to western Quebec during the day, storm warnings were ordered down at 9.30 p. m.

On the morning of the 29th small-craft warnings were ordered from Norfolk to Nantucket in connection with a disturbance that was over New Jersey and moving northward. On the evening of that date, when the disturbance was over Massachusetts with increased intensity, northwest storm warnings were ordered from Block Island to Eastport. Strong winds occurred from Hatteras northward.

On the 16th warnings for light to heavy frosts were desseminated for portions of the South Atlantic and east Gulf States and were justified. On the 19th frosts occurred quite generally in the interior of the South Atlantic and east Gulf States and in Tennessee. Warnings were issued on that date for heavy to killing frosts on the following morning in the interior of North and South Carolina and for north and central Georgia, and these frosts occurred as indicated. Frost warnings were again distributed on the 24th and 25th for portions of the Atlantic and east Gulf States. On the 29th warnings of light to heavy frost were issued for extreme northern Florida and occurred as forecast.—*R. H. Weightman.*

CHICAGO FORECAST DISTRICT

The weather, as a whole, throughout the Chicago Forecast District during November was characterized by temperatures above the normal, especially on the Great Plains, but in some areas there was a deficiency in temperature, mainly in the extreme northern Rocky Mountain region and northeastern Minnesota. There was also a deficiency of precipitation which was almost general.

Storm warnings.—In consequence of the above-mentioned mild conditions, barometric disturbances crossing the district were, for the most part, not severe, but of

only moderate or even slight intensity. Storm warnings were ordered for the Great Lakes from time to time, and these warnings were, in a large majority of cases, fully justified. As the storms were not unusual, no detailed description is necessary.

Cold-wave warnings.—No general cold-wave warnings were ordered during the month, but these advices were confined to localities in the Northwest and in the Plains States on two or three days only. The principal cold wave appeared in the Canadian Northwest on the night of the 11th, and gradually pushed southward and eastward, finally causing a considerable fall in temperature over the entire forecast district, although in middle districts it was not of cold-wave proportions.

Beekeepers' forecasts.—In response to requests received from the county agricultural agent, Phillips, Wis., and Mr. C. F. Rife, Naperville, Ill., that special forecasts be furnished them in the interests of honey producers whenever midday temperatures of 50° or more to be followed by cloudy and cooler weather were expected, advices were sent to them on November 18, indicating two days of mild temperature. On the 22d they were further advised, however, that following that date they could hardly look for any more such periods. Similar advices are being furnished to members of the American Honey Producers' League in the month of November, so that they may delay placing their bees in the cellar for the period of hibernation until there is no longer any likelihood of favorable flying weather, during which the bees may make their final cleansing flight.

Fire-weather forecasts.—Because of the prevalence of forest fires in the east-central portion of the Lower Michigan peninsula fire-weather forecasts were requested by the United States Forest Supervisor at East Tawas, Mich., on October 25, 1924, and these forecasts were continued until the fire hazard had passed, November 16. A letter from the forest supervisor states that "The forecasts have been of considerable assistance to us, and we wish to thank you for your cooperation in the matter."

During the winter season special advices, covering the probable temperature conditions during the balance of the week in the northwestern States, are sent each Monday morning to several addresses in the north Pacific States, for use in connection with the shipment of perishable fruit eastward; and whenever cold waves are imminent additional information is sent. As the temperature in that area was rather variable, ranging from fairly mild to rather cold, special attention had to be given to the service, and it is believed that the shippers interested were much benefited by the forecasts furnished. When periods of mild weather were in prospect, the shippers were, of course, so advised, as well as upon the approach of cold weather.—*H. J. Cox.*

NEW ORLEANS FORECAST DISTRICT

Cold-wave warnings were issued for Oklahoma on the 6th, and for Oklahoma and the extreme northwest portion of East Texas on the 23d, and were justified. Livestock warnings were issued for Oklahoma and the Texas Panhandle on the 6th and 13th, and for Oklahoma, the Texas Panhandle and the extreme northwest portion of East Texas on the 23d and the southern portion of West Texas on the 24th. Frost occurred as far south as the Louisiana and Texas coast on the 25th and reached the Louisiana coast on the 26th, for which timely warnings were issued; radiation was intense and frost heavy to killing almost to the coast.

No storm warnings were issued and no general storm occurred on the Gulf coast. Winds of 34 miles per hour for short periods were recorded at Galveston, Tex., during the night of the 23d–24th.—*I. M. Cline.*

DENVER FORECAST DISTRICT

Two storms which were attended by precipitation in Colorado, northern Arizona and Utah crossed the district from the northwest during the first 10 days of the month. Another disturbance, attended by light snow in western Colorado, northern Arizona and Utah, and by showers in eastern and southern New Mexico, appeared over Arizona on the 11th and advanced to Texas by the 14th. High pressures prevailed on the Rocky Mountain Plateau from the 13th to the 30th, with fair weather, except that occasional light precipitation in Colorado and northern New Mexico on the 18th, and 19th resulted from a moderate disturbance which advanced northeastward from Arizona, and light snows in central and eastern Colorado on the 23d and 26th attended moderate secondary disturbances that developed on the eastern slope of this State.

Warnings of a moderate cold wave in northeastern Arizona and southwestern Utah were issued on the morning of the 5th, and in southwestern Colorado and northern and extreme eastern New Mexico on the morning of the 6th. Warnings of a moderate cold wave in central and eastern Colorado and southwestern Utah were also issued on the morning of the 10th. All three of these warnings were verified. Another warning of a moderate cold wave, which was verified, was issued for eastern Colorado on the morning of the 26th.

At 2 p. m. of the 12th, when an area of high pressure was central over eastern Montana, with severe, low temperatures on the northeastern Rocky Mountain slope and a LOW of considerable intensity covered Arizona and northern New Mexico, warnings of a severe cold wave and livestock warnings were issued for eastern Colorado and of a moderate cold wave, with livestock warnings, for northeastern New Mexico. The cold-wave warnings were repeated on the evening of the same day. The HIGH, however, divided, the portion east of the mountains moving rapidly southeastward, while the LOW in the Southwest decreased in intensity. A moderate cold wave occurred in southeastern Colorado, with sharply lower temperatures in extreme northeastern New Mexico. Snow, a forecast of which had been included in the livestock warnings, failed to occur in eastern Colorado, although heavy rain and sleet fell at Amarillo, Tex.

Cold waves without warnings occurred at Leadville, Colo., on the 6th–7th and 23d, at Grand Junction on the 11th and in eastern New Mexico on the 24th.

Frost warnings were issued as follows: Heavy frost in south-central and southeastern Arizona on the 6th and in south-central and southwestern New Mexico on the 7th; frost in south-central and southeastern Arizona on the 7th, 11th, 24th, 25th, 27th, and 28th; frost in southern Arizona on the 12th, 13th and 26th. The warnings were generally verified.—*J. M. Sherier.*

SAN FRANCISCO FORECAST DISTRICT

At the beginning of the month the barometric pressure was abnormally high over the Alaskan area and low over the ocean east of longitude 160° west, and this situation continued during the first 10 days of the month. The result was a succession of LOWS from the ocean which

produced daily rains over the North Pacific States and a substantial rainfall in nearly all parts of California. The last of this series of LOWS passed inland on the 9th, attended by general rains over the entire State of California, and this was quickly followed by rising pressure over the ocean and falling pressure over the Aleutian Islands and the Gulf of Alaska. The storms of the first 10 days of the month made necessary the frequent display of storm warnings on the coasts of the north Pacific States and also on the north California coast. These warnings were in practically every instance verified. During the period from the 10th to the 14th the pressure rose decidedly over the region west of the Rocky Mountains and the weather became unduly cool for the season, with frequent frosts in California and freezing temperatures in other interior parts of this forecast district, but there was no appreciable damage done thereby.

From the 11th on to the 21st the pressure remained abnormally low over the Aleutian Islands and the north part of the Gulf of Alaska, and it was observed during this period that while rains were frequent in Washington and Oregon and extreme northwestern California, no rain fell elsewhere in California. While the center of this main depression was over the Alaskan region referred to, one secondary depression after another passed from it eastward, requiring frequent displays of storm warnings north of Cape Blanco. These displays were practically without exception followed by winds of gale force, with thick, rainy weather, along that part of the coast where the warnings were ordered. At the same time there was a tendency for high barometric pressure to persist over the plateau region. The most significant of these areas of maximum pressure appeared over the northwestern States on the 22d and, moving slowly east-southeastward, dominated the meteorological conditions west of the Rocky Mountains until the end of the month. It is worthy of note that this high pressure made its appearance over the Northwestern States following the eastward movement of an area of high barometer of equal magnitude which first made its appearance north of Midway Island on the 17th and 18th. In other words, the apparent period of time required for this HIGH to cross the eastern Pacific from the longitude of Midway Island was approximately between four and five days, or at the rate of 10°, in longitude, per day.

Following the 21st another deep depression moved eastward over the Aleutian Islands to the Gulf of Alaska and the pressure remained low over this area until the close of the month, during which time the pressure continued abnormally high over the region west of the Rocky Mountains, attended by generally fair weather with temperature near or somewhat below the normal in nearly all sections except southern California, where temperatures were unseasonably high.—*E. H. Bowie.*

RIVERS AND FLOODS

By H. C. FRANKENFIELD

There were no floods during the month of November except in the Willamette River of Oregon and a few of its tributary streams.

After a season that was the driest of record heavy rains set in about October 25 west of the Cascade Mountains, and during the nine-day period from October 25 to November 2, inclusive, the precipitation ranged from about 3.5 to more than 20 inches. The heaviest rains fell on the southern coast, but over portions of the Willamette Valley the fall exceeded 14 inches. As the soil was extremely dry, the floods were not severe, and flood stages were not general except in the upper tributaries. There was a second rise later in the month from some moderately heavy rains falling upon the saturated soil, and the main stream rose to higher stages than were reached during the first rise.

Warnings were issued at the proper time and no serious preventable damage occurred. The total losses reported amounted to $66,700, almost entirely to railroad property, highways and bridges.

Beginning with December 1, 1924, all published stages of water at locks and dams on the Ohio River will be referred to the zero of the *low-water* gage at each dam. Changes, where made, were for the purpose of securing uniformity and will prove of material assistance in the efficient operation of the numerous locks and dams.

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC DRAINAGE	*Feet*			*Feet*	
Santee: Rimini, S. C.	12	24	24	12.0	24
PACIFIC DRAINAGE					
Willamette:					
Eugene, Oreg.	10	1	3	14.0	1
		22	22	12.3	22
Oregon City, Oreg.	12	24	24	12.0	24
Willamette (Coast Fork) Saginaw, Oreg.	9	(1)	3	12.4	Oct. 31
Santiam: Jefferson, Oreg.	10	2	2	11.0	2
		22	22	13.8	22

1 Continued from last month.

MEAN LAKE LEVELS DURING NOVEMBER, 1924

By UNITED STATES LAKE SURVEY

[Detroit, Mich., December 3, 1924]

The following data are reported in the "Notice to Mariners" of the above date:

Data	Lakes [1]			
	Superior	Michigan and Huron	Erie	Ontario
Mean level during November, 1924:	*Feet*	*Feet*	*Feet*	*Feet*
Above mean sea level at New York	601.72	578.76	571.08	244.95
Above or below—				
Mean stage of October, 1924	−.17	−.42	−.62	−.50
Mean stage of November, 1923	−.17	−.30	+.12	.61
Average stage for November, last 10 years	−.76	−1.36	−.72	−.47
Highest recorded November stage	−1.79	−4.16	−2.59	−2.87
Lowest recorded November stage	+.22	−.30	+.38	+1.54
Average relation of the November level to—				
October level		−.2	−.2	−.2
December level		+.2	+.1	+.2

1 Lake St. Clair's level: In November, 1924, 573.74 feet.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, NOVEMBER, 1924

By J. B. KINCER

General conditions.—The first half of November was characterized by mild temperatures and very little rainfall in practically all sections east of the Rocky Mountains, and droughty conditions had become rather severe quite generally in that area. The principal effects of the deficient moisture in the interior and South were the dry-

ing out of meadows and pastures, and poor germination and growth of late-planted winter grains; while in much of the South it was too dry for seeding and for growth of late gardens and fall and winter truck. About the middle of the month, however, moderate to generous rainfall occurred in much of the Ohio Valley, western Tennessee, Arkansas, the lower Great Plains, and in the lower Missouri and middle Mississippi Valleys, largely relieving the droughty conditions in those sections. A little later in the month generous rains effectively broke the drought in the more eastern States, but no relief was reported in the central Gulf districts, where the persistent deficiency in moisture had materially reduced fall crops and delayed seeding.

Under the influence of continued mild, sunny weather seasonal farm work made exceptionally good progress except for interruption to fall plowing by lack of soil moisture in many districts. There was no material frost damage in the Southern States, as killing frost in general was later this year than the average in that area; in the southern Plains many stations reported the latest dates of record for the first killing frost in fall.

Small grains.—Winter wheat generally needed moisture during the first half of the month, especially in the wheat States east of the Mississippi River. The early-seeded wheat continued to make satisfactory progress in most sections and furnished good pasturage in the lower Missouri Valley and Kansas, but it was too dry in most sections for the late-seeded. The crop was benefited, however, in much of the principal producing area, by increased moisture about the middle of the month, while the outlook was materially improved over the middle Atlantic area during the latter part. At the close of the month the crop was in generally good condition in Illinois and most of Missouri. More moisture was needed in Iowa, Nebraska, and northern Kansas, but wheat was reported excellent in the southern half of Kansas, and conditions were generally favorable from the Rocky Mountains westward, especially in the far Northwest, where the crop was reported as doing well. In most of the Southern States it was much too dry for small grain crops, and there was considerable delay in seeding.

Corn and cotton.—The weather was generally favorable for husking and cribbing corn in the principal producing States, and this work made rapid progress during the month. In the upper Ohio Valley sections the damp weather after the middle of the month was especially helpful in shredding and husking, but a considerable quantity of corn was too soft and damp to crib. At the close of the month cribbing was well along.

November was generally warm and dry throughout the Cotton Belt, which made unusually favorable conditions for picking and ginning, and resulted in a material increase in output by enabling very close picking to be made without loss through unfavorable rain. At the close of the month harvest had been practically completed generally, except in the more northwestern and northeastern portions of the belt.

Ranges, pastures, and stock.—Meadows and pastures continued poor in central and west Gulf areas, with serious water shortage. In the central valley States meadows were unfavorably affected by lack of moisture during the first half of the month, but the latter half was more favorable. Livestock in general were favorably affected by the mild, open weather, especially in the great western grazing districts, though continued drought in the Southwest was decidedly deterimental to ranges.

Miscellaneous crops.—Winter truck crops did well in the Pacific Coast States, and the weather was favorable for irrigated truck in the west Gulf area. Elsewhere in the South gardens and late truck were seriously affected by the continued lack of moisture, although they did fairly well in most of the south Atlantic districts. In Louisiana sugar cane continued in poor condition, and the short crop resulted in some factories being idle. The harvest of sugar beets made satisfactory progress quite generally, while for potato digging in the Northeast the first part of the month had excellent weather.

CLIMATOLOGICAL TABLES[1]

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, November, 1924

Section	Temperature: Section average	Temperature: Departure from the normal	Monthly extremes: Station	Highest	Date	Station	Lowest	Date	Precipitation: Section average	Precipitation: Departure from the normal	Greatest monthly: Station	Amount	Least monthly: Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	56.2	+1.5	Selma	90	3	St. Bernard	13	26	0.25	−2.78	Riverton	0.87	5 stations	0.00
Alaska (October)	30.2	−3.4	Annex Creek	64	1	Allakaket	−21	19	7.90	+0.59	Cordova	26.97	Fairbanks (near)	0.82
Arizona	53.4	+1.5	Mohawk	100	[2] 2	2 stations	4	[2] 23	0.17	−0.72	Lakeside	1.23	33 stations	0.00
Arkansas	53.4	+1.9	4 stations	88	[2] 2	do	15	[2] 25	2.36	−1.21	Hot Springs	5.60	Huttig	0.20
California	52.5	−0.3	3 stations	99	[2] 2	Summit	5	11	2.27	−0.33	Upper Mattole	14.43	9 stations	0.00
Colorado	36.6	+1.0	Holly	87	5	Cathedral	−22	11	0.49	−0.39	Savage Basin	3.45	11 stations	0.00
Florida	65.1	−0.1	McDonald	88	7	2 stations	23	26	0.54	−2.04	Allapattah	4.35	2 stations	0.00
Georgia	55.9	+1.2	Milledgeville	87	8	Blue Ridge	14	26	0.72	−1.93	Greensboro	2.29	Fort Gaines	T.
Hawaii	71.5	−0.1	Mahukona	91	5	Volcano Observatory	47	4	7.66	−1.50	Umikoa	40.82	2 stations	0.00
Idaho	34.4	−0.9	3 stations	78	[2] 2	Obsidian	−11	13	2.09	−0.08	Musselshell Ranger Station.	8.10	Springfield	T.
Illinois	43.4	+1.5	2 stations	85	4	Galva	3	29	1.23	−1.17	Casey	2.64	Kankakee	0.41
Indiana	43.0	+0.9	Marengo	86	6	South Bend	7	17	1.43	−1.63	Terre Haute	2.85	Rochester	0.50
Iowa	38.9	+2.3	Belle Plaine	82	1	2 stations	0	29	0.58	−0.98	Washington	1.55	4 stations	T.
Kansas	45.7	+1.7	Garden City	91	5	Tribune	5	25	0.72	−0.43	Walnut	4.00	3 stations	0.00
Kentucky	47.7	+1.4	3 stations	83	[2] 2	Anchorage	13	29	1.82	−1.71	Burnside	3.86	Carrollton	0.72
Louisiana	61.5	+2.6	Ruston	92	12	Kelly (near)	18	25	0.64	−2.85	Franklin	2.84	4 stations	0.00
Maryland-Delaware	44.7	+0.3	2 stations	79	7	2 stations	10	19	1.84	−0.68	Millsboro, Del	2.79	2 stations	1.29
Michigan	37.3	+1.2	do	80	[2] 1	Chatham	−8	16	2.23	−0.23	Mancelona	6.70	Pontiac	0.41
Minnesota	29.5	−0.3	Zumbrota	75	1	Itasca State Park	−8	28	0.44	−0.71	Reeds	1.20	Alexandria	0.00
Mississippi	57.9	+2.8	Fayette	90	7	Port Gibson	16	26	0.45	−3.03	Austin	2.72	5 stations	0.00
Missouri	46.7	+2.2	Brunswick	88	6	Clifton Hill	4	29	1.72	−0.63	Caruthersville	4.11	Farmington	0.51
Montana	31.4	−0.4	Biddle	80	2	Kinread	−30	13	1.28	+0.25	Haugan	6.35	Crow Agency	0.00
Nebraska	39.3	+2.6	Central City	84	1	Gordon	0	7	0.26	−0.49	Hay Springs	1.32	Aurora	0.00
Nevada	39.9	−0.4	Logandale	88	2	San Jacinto	−15	13	0.50	−0.12	Carson City	2.06	4 stations	0.00
New England	38.6	+1.4	Turner's Falls, Mass.	78	1	Somerset, Vt	−12	20	2.69	−0.66	Berlin, N. H	5.61	Portland, Me	0.91
New Jersey	42.9	−0.2	2 stations	77	[2] 2	Runyon	1	18	2.03	−1.07	Tuckerton	3.23	South Orange	1.17
New Mexico	45.2	+2.5	Carlsbad	89	4	Luna Ranger Station	−5	[2] 24	0.35	−0.42	Lindrith	1.30	19 stations	0.00
New York	38.7	+1.1	2 stations	75	[2] 6	De Ruyter	−7	18	2.22	−0.67	Taberg	5.62	Dansville	0.39
North Carolina	50.4	+1.3	Louisberg	86	14	Mt. Mitchell	3	29	1.41	−1.00	Hatteras	3.45	Mt. Mitchell	0.30
North Dakota	27.6	+1.0	2 stations	69	[2] 9	Howard	−15	13	0.18	−0.40	Howard	0.85	2 stations	0.00
Ohio	41.4	−0.1	3 stations	79	7	2 stations	6	29	1.44	−1.16	Piqua	2.99	Norwalk	0.44
Oklahoma	52.9	+2.7	Altus	91	5	Goodwell	12	27	1.74	−0.30	Newkirk	4.12	2 stations	T.
Oregon	40.5	−0.7	Medford	76	1	2 stations	−2	[2] 12	5.31	+0.71	Willow Creek	21.88	Andrews	0.25
Pennsylvania	40.7	−0.1	2 stations	78	7	West Bingham	−9	18	1.54	−1.11	Gouldsboro	3.29	Mifflintown	0.56
Porto Rico	77.0	+0.2	Lares	97	10	Aibonito	57	[2] 19	11.69	+4.48	Yabucoa	22.83	Camuy	5.20
South Carolina	54.4	+0.6	Society Hill	87	13	Clemson College	21	26	1.35	−0.90	Edgefield	2.95	Georgetown	0.15
South Dakota	35.1	+2.0	Britton	79	1	McLaughlin	−10	12	0.44	−0.17	Harveys Ranch	1.90	8 stations	T.
Tennessee	50.1	+1.6	2 stations	84	[2] 2	Crossville	8	29	1.61	−1.79	Celina	3.06	Loudon	0.28
Texas	60.9	+3.9	Hondo	99	2	Clint	12	[2] 25	0.69	−1.70	Dallas	3.36	37 stations	0.00
Utah	36.2	−1.2	St. George	86	3	Castle Rock	−13	13	0.79	−0.18	Silver Lake	2.61	Hurricane	0.00
Virginia	47.1	+0.4	Runnymede	80	14	Mineral	11	26	1.99	−0.33	Burkes Garden	3.40	Callaville	1.09
Washington	38.1	−1.8	Sunnyside	69	23	2 stations	−4	12	4.90	+0.18	Wind River	18.32	Prosser	0.93
West Virginia	42.9	−0.2	Union	87	4	Terra Alta	9	19	2.05	−0.54	Pickens	4.11	Upper Tract	0.45
Wisconsin	33.9	+0.4	Ripon	77	5	Ashland	−9	14	1.71	−0.14	West Bend	3.37	Downing	T.
Wyoming	32.4	+0.2	Salt Creek	85	4	Riverside	−23	[2] 13	0.76	+0.13	Crandall Creek	4.62	4 stations	T.

[1] For description of tables and charts, see REVIEW, January, 1924, pp. 56-57.
[2] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, November, 1924*

Districts and stations	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature: Departure from normal	Temperature: Maximum	Temperature: Date	Temperature: Mean maximum	Temperature: Minimum	Temperature: Date	Temperature: Mean minimum	Temperature: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
New England	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles								0–10	In.	In.
							41.2	+1.7										73	1.95	−1.6										5.6		
Eastport	76	67	85	29.88	29.96	−.05	39.1	+2.4	58	12	45	14	17	33	24	35	32	76	1.59	−2.5	8	8,683	sw.	52	ne.	30	4	12	14	7.0	4.9	4.0
Greenville, Me	1,070	6	-----	-----	-----	-----	33.0	-----	62	1	42	0	19	24	37	-----	-----	-----	4.47	-----	11	-----	se.	-----	-----	-----	6	4	20	-----	9.6	-----
Portland, Me	103	82	117	29.89	30.02	+.01	40.2	+2.2	72	7	47	13	17	33	29	35	29	70	0.91	−2.9	7	7,205	sw.	42	se.	23	14	4	12	5.0	1.8	1.2
Concord	288	70	79	29.69	30.02	−.04	37.6	−0.1	75	7	47	4	19	28	35	-----	-----	-----	1.89	−1.5	8	3,916	nw.	28	nw.	17	13	5	12	5.3	4.3	3.5
Burlington	404	11	48	29.56	30.01	−.04	37.6	+1.3	69	7	44	7	17	31	36	-----	-----	-----	2.39	−0.2	6	11,858	s.	50	s.	6	2	10	18	7.6	4.8	3.5
Northfield	876	12	60	29.04	30.02	−.03	35.2	+2.4	72	7	45	−2	19	26	43	31	27	76	2.55	0.0	6	7,011	s.	38	sw.	7	5	9	16	7.1	7.3	4.0
Boston	125	115	188	29.88	30.02	−.03	44.6	+2.6	76	7	52	14	17	37	27	40	35	73	1.93	−2.2	5	7,601	sw.	37	w.	17	11	10	9	5.3	0.5	0.2
Nantucket	12	14	90	30.02	30.03	−.02	44.9	+0.5	65	12	51	17	17	39	22	42	38	78	2.76	−0.5	8	12,298	sw.	51	w.	17	9	11	10	5.4	0.0	0.0
Block Island	26	11	46	30.01	30.04	−.02	45.0	+0.4	64	12	50	15	17	40	22	41	37	73	2.01	−1.9	7	14,599	sw.	66	nw.	16	11	4	15	6.2	0.0	0.0
Providence	160	215	251	29.86	30.04	−.03	43.2	+2.8	71	7	51	14	17	35	26	38	31	66	1.48	−2.4	5	8,505	nw.	68	nw.	17	15	7	8	4.4	T.	T.
Hartford	159	122	140	29.86	30.04	−.04	42.2	+2.7	70	7	51	6	17	34	32	-----	-----	-----	1.96	−1.9	8	-----	s.	-----	-----	-----	15	7	8	4.3	0.9	0.1
New Haven	106	74	153	29.94	30.05	−.02	43.0	+1.0	68	2	50	14	19	36	26	38	32	69	2.00	−1.6	7	7,428	sw.	42	se.	22	18	5	7	4.0	T.	0.0
Middle Atlantic States							45.2	+0.5										71	1.87	−1.0										5.3		
Albany	97	102	115	29.94	30.05	−.03	40.4	+1.1	72	7	48	10	17	33	31	35	30	73	2.76	0.0	8	5,381	s.	33	s.	5	12	6	12	5.2	2.9	2.0
Binghamton	871	10	84	29.09	30.04	−.05	39.2	+0.5	72	7	48	10	18	31	30	-----	-----	-----	1.62	−0.6	8	4,692	sw.	31	nw.	16	8	4	18	6.5	2.2	0.7
New York	314	414	454	29.73	30.07	−.02	44.1	−0.1	68	2	51	18	17	37	25	38	31	64	2.04	−1.4	4	13,639	nw.	7	nw.	16	7	15	8	5.6	T.	0.0
Harrisburg	374	94	104	29.71	30.12	+.02	43.0	+0.2	74	7	51	18	19	35	31	36	30	65	1.63	−0.7	5	4,024	w.	39	nw.	16	10	7	13	5.6	0.6	0.6
Philadelphia	114	123	190	29.98	30.11	+.01	46.4	+0.7	73	2	54	22	17	39	28	40	32	62	1.75	−1.3	7	6,894	sw.	36	nw.	16	9	7	14	5.9	T.	T.
Reading	325	81	98	29.74	30.10	-----	43.6	-----	74	7	52	19	18	35	27	38	34	75	1.44	−1.7	6	3,860	nw.	26	nw.	16	13	11	6	5.1	0.5	0.3
Scranton	805	111	119	29.21	30.09	.00	40.9	+0.4	71	7	49	14	19	33	32	36	33	82	1.63	−0.7	7	5,616	sw.	38	w.	17	7	11	12	6.1	1.7	0.6
Atlantic City	52	37	172	30.04	30.10	.00	46.7	+1.1	72	4	54	20	19	40	22	42	37	71	2.55	−0.7	5	12,708	nw.	62	s.	22	13	8	9	4.5	T.	0.0
Cape May	17	13	49	30.11	30.13	+.03	47.0	−0.4	70	7	54	21	19	40	23	43	38	75	2.19	−1.0	5	6,356	nw.	40	se.	22	15	4	11	4.7	T.	0.0
Sandy Hook	22	10	55	30.05	30.07	-----	44.6	-----	68	2	50	21	17	39	23	39	33	68	2.14	-----	5	12,372	sw.	61	nw.	17	10	11	9	5.2	T.	0.0
Trenton	190	159	183	29.88	30.09	-----	44.1	-----	70	2	52	19	17	36	27	38	33	71	1.58	−1.8	6	7,857	sw.	44	nw.	17	12	8	10	5.3	T.	T.
Baltimore	123	100	113	29.97	30.11	.00	47.0	+0.7	76	2	55	26	17	39	31	40	33	64	1.37	−1.6	7	3,732	sw.	19	sw.	24	10	11	9	5.3	0.2	0.1
Washington	112	62	85	30.00	30.12	.00	46.0	+0.8	76	2	55	23	19	38	34	39	33	67	1.47	−1.2	7	4,364	nw.	30	nw.	16	6	10	14	6.0	T.	T.
Cape Henry	18	8	54	30.09	30.11	-----	51.6	-----	79	6	58	30	30	45	31	46	43	78	2.43	−0.3	4	10,362	sw.	49	n.	2	13	8	9	4.9	T.	0.0
Lynchburg	681	153	188	29.37	30.13	.00	47.7	+0.5	79	4	58	23	26	37	41	41	35	70	1.45	−1.3	6	5,107	w.	32	n.	16	15	7	8	4.8	0.7	0.0
Norfolk	91	170	205	30.03	30.13	+.02	51.6	+0.2	76	6	59	28	30	44	28	45	41	74	2.00	−0.7	6	9,251	ne.	42	nw.	22	14	7	9	4.8	0.3	0.0
Richmond	144	11	52	29.98	30.13	+.01	48.8	+0.5	77	7	58	25	26	39	34	42	38	73	1.61	−0.8	5	5,679	ne.	33	nw.	16	15	5	10	4.9	0.3	0.0
Wytheville	2,304	49	55	27.72	30.15	+.02	44.2	+1.2	70	6	54	22	30	35	33	38	34	76	2.25	−0.8	8	4,924	w.	29	w.	30	14	7	9	4.9	0.5	T.
South Atlantic States							55.4	+1.2										76	1.20	−1.5										2.9		
Asheville	2,255	70	84	27.76	30.16	+.02	47.8	+2.7	73	7	59	21	26	37	39	40	35	71	0.41	−1.9	1	6,225	se.	33	n.	30	19	5	6	3.1	T.	0.0
Charlotte	779	55	62	29.29	30.14	+.01	52.2	+1.6	79	14	62	26	19	42	29	45	40	72	1.37	−1.5	4	3,516	sw.	24	nw.	22	21	3	6	2.8	0.0	0.0
Hatteras	11	11	50	30.10	30.11	.00	56.2	−0.1	77	6	62	36	20	50	22	52	49	81	3.45	−1.2	4	10,733	n.	46	w.	29	13	10	7	4.6	0.0	0.0
Manteo	12	5	42	-----	-----	-----	52.6	-----	80	6	-----	26	20	-----	34	-----	-----	-----	1.76	-----	3	-----	ne.	-----	-----	-----	19	4	7	-----	0.0	0.0
Raleigh	376	103	110	29.73	30.14	+.01	51.7	+0.7	78	14	62	28	18	42	30	45	40	72	1.69	−0.7	4	5,611	sw.	28	nw.	29	17	6	7	3.9	0.2	0.0
Wilmington	78	81	91	30.07	30.16	+.04	56.4	+0.4	81	14	67	30	30	46	28	50	46	79	1.34	−1.1	3	4,623	n.	26	sw.	24	19	8	3	2.7	0.0	0.0
Charleston	48	11	92	30.10	30.15	+.03	58.8	+0.7	80	15	67	34	30	50	24	53	50	82	0.72	−2.2	3	6,702	n.	37	sw.	22	19	4	7	3.2	0.0	0.0
Columbia, S. C	351	41	57	29.77	30.16	+.04	55.6	+1.6	82	14	66	30	30	45	30	48	43	72	0.95	−1.3	2	4,219	ne.	39	sw.	21	24	4	2	2.3	0.0	0.0
Due West	711	10	55	29.40	30.18	-----	52.5	-----	80	14	63	28	19	42	30	-----	-----	-----	1.67	-----	3	5,787	sw.	35	w.	15	25	3	2	2.1	0.0	0.0
Greenville, S. C	1,039	113	122	29.02	30.13	-----	52.2	+2.6	77	14	62	28	30	42	28	45	40	70	0.81	-----	2	4,967	sw.	34	w.	22	25	2	3	2.3	0.0	0.0
Augusta	180	62	77	29.96	30.15	+.02	56.0	+1.5	82	14	67	31	26	45	31	50	47	83	1.16	−1.8	3	3,229	nw.	25	nw.	29	22	6	2	2.7	0.0	0.0
Savannah	65	150	194	30.08	30.15	+.03	59.7	+1.2	81	15	69	32	30	50	28	52	48	77	0.48	−1.9	3	7,919	w.	46	nw.	22	23	3	4	2.2	0.0	0.0
Jacksonville	43	200	245	30.10	30.15	+.05	62.4	+0.2	81	15	70	36	30	54	24	55	51	76	0.38	−1.8	6	9,036	ne.	48	n.	22	20	6	4	3.2	0.0	0.0
Florida Peninsula							70.7	−0.4										74	0.46	−1.9										3.6		
Key West	22	10	64	30.04	30.06	+.04	73.4	−0.9	82	7	77	60	30	69	13	67	64	77	0.07	−2.3	3	8,616	ne.	34	nw.	22	17	9	4	3.4	0.0	0.0
Miami	25	71	79	30.05	30.08	-----	71.6	−0.4	80	8	77	50	30	66	21	64	61	72	1.06	−1.8	8	6,750	ne.	27	w.	22	12	12	6	4.4	0.0	0.0
Sand Key	23	39	72	30.04	30.07	+.05	73.4	-----	79	7	76	62	30	71	10	67	63	72	0.46	-----	3	14,633	ne.	39	ne.	25	19	7	4	3.2	0.0	0.0
Tampa	35	79	87	30.09	30.13	+.05	67.0	+0.1	83	7	76	39	30	58	28	59	56	76	0.24	−1.5	2	5,054	ne.	28	nw.	22	17	10	3	3.4	0.0	0.0
East Gulf States							58.5	+2.3										70	0.28	−3.2										2.6		
Atlanta	1,174	190	216	28.91	30.16	+.03	54.6	+2.5	77	14	63	29	29	46	26	47	41	66	0.64	−2.8	2	8,025	nw.	40	nw.	30	19	7	4	2.7	0.0	0.0
Macon	370	78	87	29.76	30.17	+.04	55.2	+1.0	81	14	67	26	26	43	32	47	43	73	1.20	−1.9	3	3,832	nw.	25	nw.	21	20	7	3	2.5	0.0	0.0
Thomasville	273	49	58	29.86	30.16	+.04	60.2	+1.7	82	14	71	32	26	49	31	51	46	72	0.32	−2.3	2	2,777	ne.	20	nw.	22	20	6	4	2.7	0.0	0.0
Apalachicola	36	42	49	30.12	30.16	-----	61.8	-----	78	15	70	37	26	54	25	56	52	79	1.02	-----	2	4,943	nw.	31	nw.	22	25	2	3	1.7	0.0	0.0
Pensacola	56	149	185	30.11	30.17	+.06	62.0	+1.8	80	9	70	37	25	54	25	56	52	76	0.17	−3.6	2	8,361	e.	33	sw.	24	21	7	2	2.4	0.0	0.0
Anniston	741	9	57	29.40	30.20	+.08	53.4	+1.5	80	14	66	21	26	40	42	-----	-----	-----	0.12	−3.3	3	3,323	s.	24	nw.	29	19	6	5	2.7	0.0	0.0
Birmingham	700	11	48	29.41	30.19	+.07	55.9	+2.0	80	14	67	28	29	45	31	46	39	62	0.01	−3.4	1	4,576	nw.	26	s.	23	25	3	2	1.7	0.0	0.0
Mobile	57	125	161	30.11	30.17	+.06	61.6	+2.6	81	1	72	31	26	52	29	54	50	75	0.06	−3.7	1	6,346	n.	29	nw.	24	15	14	1	3.3	0.0	0.0
Montgomery	223	100	112	29.92	30.18	+.06	57.8	+2.0	81	3	69	30	26	46	31	49	42	65	0.19	−2.9	2	3,964	nw.	27	n.	21	22	6	2	2.0	0.0	0.0
Corinth	469	6	-----	-----	-----	-----	54.4	-----	81	4	67	24	29	42	44	-----	-----	-----	1.08	-----	7	-----	se.	-----	-----	-----	10	14	6	-----	0.0	0.0
Meridian	375	85	93	29.77	30.17	+.05	57.0	+2.8	80	1	69	26	26	44	37	48	43	69	0.17	−4.0	1	3,294	e.	24	nw.	23	19	9	2	2.7	0.0	0.0
Vicksburg	247	65	73	29.90	30.19	+.07	59.8	+3.2	82	12	70	34	25	50	29	51	45	66	T.	−4.2	0	4,689	se.	32	nw.	23	14	8	8	4.0	0.0	0.0
New Orleans	53	76	84	30.12	30.17	+.07	65.5	+3.9	82	15	74	44	30	57	30	57	52	70	0.23	−3.6	4	4,152	se.	18	sw.	23	17	12	1	3.3	0.0	0.0
West Gulf States							61.9	+4.2										70	1.00	−2.1										3.6		
Shreveport	249	77	93	29.80	30.17	+.06	59.2	+3.2	84	5	70	32	28	48	35	51	45	67	0.33	−3.8	3	4,608	se.	28	s.	5	14	10	6	3.7	0.0	0.0
Bentonville	1,303	11	44	-----	-----	-----	50.8	+4.1	79	2	62	25	29	40	37	-----	-----	-----	2.21	-----	6	2,832	s.	22	s.	6	19	6	5	-----	0.4	0.0
Fort Smith	457	79	94	29.63	30.12	+.01	54.0	+3.0	82	5	65	27	25	43	37	46	39	65	0.89	−2.4	4	6,182	e.	40	sw.	7	13	8	9	4.7	T.	0.0
Little Rock	357	136	144	29.76	30.14	+.02	54.2	+2.1	80	2	64	30	25	44	34	46	39	63	2.54	−2.0	6	6,517	s.	37	nw.	23	14	8	8	4.4	0.0	0.0
Brownsville	57	53	61	30.04	30.10	-----	72.2	+5.0	86	20	80	44	25	64	29	64	62	80	0.03	-----	2	5,348	s.	27	sw.	23	15	12	3	3.5	0.0	0.0
Corpus Christi	20	11	73	30.12	30.14	+.07	70.4	+6.1	88	23	77	43	25	64	27	64	62	81	0.06	−2.4	2	9,217	se.	38	n.	23	13	16	1	3.6	0.0	0.0
Dallas	512	109	117	29.60	30.16	-----	59.0	-----	84	5	70	35	27	48	38	-----	-----	-----	3.36	-----	4	5,824	s.	33	s.	5	16	5	9	4.1	0.0	0.0
Fort Worth	670	106	114	29.41	30.12	+.02	59.2	+3.7	85	5	70	35	29	48	38	50	42	61	1.60	0.0	6	6,813	s.	36	s.	5	16	9	5	3.7	0.0	0.0
Galveston	54	106	114	30.11	30.17	+.08	67.4	+4.1	79	7	73	48	25	62	19	62	58	75	1.52	−2.5	5	7,676	s.	34	n.	24	20	6	4	2.6	0.0	0.0
Groesbeck	461	11	56	29.66	30.15	-----	60.0	-----	87	6	72	31	25	48	41	-----	-----	-----	2.60	-----	4	7,599	s.	40	sw.	5	19	3	8	3.3	0.0	0.0
Houston	138	111	121	30.01	30.16	-----	66.2	+5.2	83	7	76	41	25	56	31	-----	-----	-----	1.35	-----	5	5,078	se.	24	e.	20	16	8	6	3.9	0.0	0.0
Palestine	510	64	72	29.62	30.16	+.05	60.7	+3.5	84	5	72	36	28	50	32	52	46	67	1.49	−2.1	5	5,377	n.	27	s.	6	13	12	5	3.8	0.0	0.0
Port Arthur	34	58	66	30.11	30.16	-----	65.5	-----	80	14	73	37	25	58	27	59	56	80	2.19	-----	3	6,388	se.	42	nw.	20	17	12	1	3.0	0.0	0.0
San Antonio	693	119	132	29.40	30.13	+.05	66.5	+6.2	86	14	77	36	25	56	34	56	49	61	0.24	−1.5	2	5,661	ne.	32	nw.	23	15	10	5	3.6	0.0	0.0
Taylor	583	55	63	29.56	30.17	+.09	62.4	+4.7	86	13	75	31	25	50	36	-----	-----	-----	0.36	−2.3	3	6,185	s.	31	s.	26	19	5	6	3.2	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, November, 1924*—Continued

Districts and stations	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
Ohio Valley and Tennessee	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
							46.0	**+0.8**										**69**	**1.51**	**-2.0**										**6.0**		
Chattanooga	762	189	213	29.34	30.17	+.03	52.6	+2.2	78	2	62	25	29	43	32	44	37	62	1.01	-2.6	5	4,830	sw.	36	nw.	30	15	10	5	3.8	0.0	0.0
Knoxville	996	102	111	29.07	30.15	+.02	50.7	+2.8	74	7	60	26	26	41	31	44	40	74	0.79	-2.8	5	3,992	sw.	25	ws.	23	11	6	13	5.4	T.	0.0
Memphis	399	76	97	29.72	30.15	+.03	53.8	+2.1	79	4	62	30	20	45	29	46	38	62	2.94	-1.6	6	3,904	se.	30	nw.	15	15	5	10	4.1	0.0	0.0
Nashville	546	168	191	29.57	30.17	+.05	50.0	+1.0	78	2	59	26	26	41	40	43	38	69	1.25	-2.6	6	6,532	s.	36	nw.	22	12	9	9	4.8	0.0	0.0
Lexington	989	193	230	29.05	30.14	+.02	45.0	+0.2	74	4	53	21	29	37	31	----	----	----	1.32	-3.2	10	9,765	sw.	40	sw.	6	7	7	16	6.6	0.8	T.
Louisville	525	188	234	29.54	30.14	+.02	46.6	-0.1	75	4	54	23	29	39	32	40	33	63	1.00	-3.2	8	8,463	s.	36	s.	26	8	9	13	5.9	0.2	0.0
Evansville	431	139	175	29.66	30.14	+.02	47.4	+0.8	76	6	56	23	29	39	33	41	35	68	1.40	-3.1	7	8,625	sw.	38	sw.	6	6	16	8	5.7	0.3	0.0
Indianapolis	822	194	230	29.20	30.10	.00	42.6	+0.3	74	6	50	19	29	35	33	37	33	73	1.75	-1.8	9	9,694	sw.	38	nw.	7	6	16	8	6.0	0.5	0.0
Royal Center	736	11	55	29.25	30.07	----	39.5	----	74	6	48	12	29	31	36	----	----	----	0.88	----	7	8,719	w.	35	w.	7	6	9	15	6.6	2.3	0.6
Terre Haute	575	96	129	29.47	30.10	----	43.7	----	76	6	52	21	29	36	34	38	32	71	2.85	----	9	8,146	s.	37	w.	21	6	14	10	6.1	1.5	0.0
Cincinnati	628	11	61	29.43	30.12	.00	43.6	+1.1	76	6	52	22	29	36	38	----	34	70	1.05	-2.2	9	6,220	sw.	33	sw.	27	7	9	14	6.4	0.5	T.
Columbus	824	179	222	29.21	30.11	.00	41.3	-0.6	73	7	49	19	29	34	33	36	32	70	1.86	-1.2	10	8,035	w.	38	w.	27	5	13	12	6.4	4.0	1.9
Dayton	899	137	173	29.12	30.10	----	41.8	-0.2	73	6	49	19	30	34	34	37	31	69	1.45	-1.4	11	8,139	sw.	38	w.	7	7	9	14	6.4	1.9	0.4
Elkins	1,947	59	67	28.04	30.15	+.03	41.0	+0.7	73	6	52	16	26	30	42	35	30	75	2.65	-0.2	13	4,103	w.	26	nw.	16	6	4	20	7.2	6.4	5.0
Parkersburg	638	77	84	29.47	30.14	+.02	44.6	+0.8	75	7	53	22	18	36	31	38	33	71	1.67	-1.2	10	4,307	sw.	30	nw.	7	5	8	17	7.2	2.9	1.6
Pittsburgh	842	353	410	29.18	30.11	+.01	42.8	-0.4	73	7	50	19	30	36	30	37	32	70	1.39	-1.2	10	8,906	sw.	46	nw.	16	7	7	16	6.7	1.2	0.7
Lower Lake Region							**40.0**	**+0.6**										**71**	**1.33**	**-1.7**										**6.3**		
Buffalo	767	247	280	29.18	30.03	-.02	39.8	+0.4	67	7	47	16	17	33	31	36	32	77	1.90	-1.4	12	15,854	sw.	66	w.	7	5	10	15	6.9	13.2	8.0
Canton	448	10	61	29.49	29.98	----	36.2	+2.3	71	7	44	6	17	29	31	----	----	----	2.94	-0.5	9	9,607	sw.	53	sw.	2	5	7	18	6.9	8.7	1.4
Oswego	335	76	91	----	30.01	-.04	39.6	+0.7	71	7	46	13	17	33	27	----	----	70	1.68	-1.7	11	----	s.	40	nw.	17	5	8	17	----	10.6	6.5
Rochester	523	86	102	29.45	30.03	-.02	40.4	+1.7	73	7	48	16	17	33	28	35	28	66	0.48	-2.3	10	7,043	sw.	37	sw.	7	8	5	17	6.8	1.1	0.2
Syracuse	597	97	113	29.39	30.04	-.02	39.4	+0.7	72	7	46	10	18	33	25	----	----	----	1.93	-0.8	10	8,117	s.	42	nw.	16	4	8	18	7.1	8.5	4.2
Erie	714	130	166	29.25	30.04	-.02	41.2	-0.2	73	7	48	18	30	34	33	37	32	72	1.48	-2.1	12	13,723	s.	46	nw.	16	5	7	18	7.1	8.0	3.0
Cleveland	762	190	201	29.22	30.06	-.01	41.2	+0.3	75	6	49	20	30	34	32	36	31	70	0.91	-1.8	9	10,813	sw.	48	nw.	16	6	9	15	6.4	2.4	2.0
Sandusky	629	62	70	29.37	30.06	-.02	41.2	+0.1	76	6	49	18	30	34	34	----	----	----	0.66	-2.1	7	6,980	sw.	35	nw.	7	5	14	11	5.9	0.5	0.5
Toledo	628	208	243	29.36	30.06	-.01	40.6	+0.2	74	6	48	14	30	33	33	35	30	68	0.75	-1.9	7	12,359	sw.	54	sw.	7	12	10	8	4.8	0.4	T.
Fort Wayne	856	113	124	29.13	30.07	----	40.7	+0.1	74	6	49	15	30	33	32	35	30	72	1.03	----	9	7,903	sw.	37	w.	7	11	7	12	5.6	5.9	1.1
Detroit	730	218	258	29.23	30.04	-.02	39.8	+0.5	71	6	47	14	30	32	33	35	30	70	0.60	-2.0	11	9,638	sw.	49	sw.	7	7	13	10	5.9	1.0	0.5
Upper Lake Region							**35.9**	**+0.4**										**76**	**1.58**	**-0.8**										**7.1**		
Alpena	609	13	92	29.27	29.94	-.07	36.2	+1.8	72	1	43	12	17	29	31	32	29	80	2.63	+0.1	13	9,445	sw.	46	nw.	16	1	11	18	7.8	3.9	0.8
Escanaba	612	54	60	29.26	29.94	-.02	33.6	+0.5	69	1	41	11	17	27	32	30	25	74	1.28	-1.0	8	8,532	nw.	33	n.	6	5	9	16	6.5	1.6	0.2
Grand Haven	632	54	89	29.30	29.99	-.05	39.0	+0.5	68	5	46	13	30	32	33	36	32	76	1.84	-0.7	15	11,377	w.	46	nw.	16	6	6	18	7.4	9.4	3.7
Grand Rapids	707	70	87	29.23	30.01	-.04	39.7	+1.6	72	6	47	12	30	32	33	35	30	70	1.60	-9.9	13	5,376	nw.	36	nw.	7	3	9	18	7.9	7.1	4.0
Houghton	668	62	99	29.16	29.90	-.12	32.5	+0.5	59	5	38	13	17	27	29	----	----	----	2.32	-0.5	16	9,077	w.	52	w.	1	1	8	21	8.1	17.2	7.0
Lansing	878	11	62	29.05	30.01	----	37.8	+0.3	74	6	47	9	30	29	33	33	28	74	0.89	-1.5	8	5,972	sw.	25	sw.	1	9	6	15	6.0	3.1	2.0
Ludington	637	60	66	29.26	29.97	----	37.9	----	65	5	44	18	30	30	28	33	28	73	2.72	----	14	10,626	w.	38	s.	11	5	5	20	7.2	10.7	6.1
Marquette	734	77	111	29.12	29.94	-.08	33.8	+0.5	66	5	41	11	16	27	31	30	26	77	2.02	-0.8	12	9,212	w.	28	sw.	5	4	7	19	7.6	9.5	1.5
Port Huron	638	70	120	29.30	30.00	-.05	38.4	+0.9	69	6	46	14	30	31	32	34	30	74	0.58	-2.1	8	10,084	sw.	49	nw.	16	5	11	14	6.5	1.4	1.0
Saginaw	641	69	77	29.29	30.00	----	38.0	+0.6	73	6	46	12	30	30	34	34	30	76	0.61	-1.7	6	7,943	sw.	37	sw.	1	3	10	17	7.5	0.5	0.4
Sault Sainte Marie	614	11	52	29.20	29.92	-.09	31.8	-0.2	57	1	38	7	30	26	25	30	28	86	3.36	+0.4	16	7,509	nw.	46	nw.	1	2	4	24	8.6	12.5	2.3
Chicago	823	140	310	29.13	30.04	-.03	41.5	+0.3	75	5	49	12	29	34	34	36	30	64	0.86	-1.6	8	10,167	w.	39	sw.	5	9	11	10	5.4	1.0	0.1
Green Bay	617	109	144	29.27	29.95	-.03	35.0	+0.1	71	5	42	8	28	28	31	31	27	75	2.01	0.0	11	9,514	sw.	39	s.	11	5	9	16	6.8	1.9	0.2
Milwaukee	681	125	139	29.25	30.00	-.05	38.0	+0.7	72	5	46	12	29	30	27	34	30	75	1.58	-0.4	10	8,315	w.	35	se.	17	10	4	16	6.4	5.0	0.9
Duluth	1,133	5	47	28.70	29.96	-.08	27.2	-2.8	57	1	35	4	28	19	29	24	21	83	0.47	-1.1	9	10,492	w.	48	nw.	24	7	8	15	6.5	2.6	0.5
North Dakota							**27.8**	**+1.4**										**75**	**0.25**	**-0.5**										**6.0**		
Moorhead	940	50	58	28.97	30.02	-.05	27.9	+0.8	60	19	37	5	28	19	37	24	19	71	0.19	-0.8	8	6,950	nw.	33	se.	8	6	11	13	6.1	2.3	T.
Bismarck	1,674	8	57	28.24	30.08	+.01	30.8	+2.3	64	19	41	2	13	21	40	26	21	72	0.05	-0.6	2	7,685	nw.	40	nw.	20	7	10	13	5.9	0.2	0.0
Devils Lake	1,478	11	44	28.38	30.01	-.05	23.8	+1.2	58	19	32	-4	28	16	31	21	18	80	0.38	-0.3	9	8,355	nw.	39	w.	20	8	9	13	6.1	4.4	0.5
Ellendale	1,457	10	56	28.42	30.02	----	30.2	----	62	19	40	7	28	20	44	----	----	----	0.12	----	5	10,911	nw.	46	nw.	21	7	5	18	6.7	1.4	0.0
Grand Forks	835	12	89	----	----	----	25.4	----	56	19	34	5	28	17	37	22	----	----	0.17	----	3	----	nw.	51	s.	8	9	6	15	5.8	2.2	0.0
Williston	1,878	41	48	28.01	30.05	-.01	28.6	+1.4	55	19	37	-1	13	20	30	25	21	76	0.38	-0.2	3	7,182	w.	48	w.	19	7	12	11	5.6	2.4	0.0
Upper Mississippi Valley							**40.1**	**+1.7**										**71**	**1.06**	**-1.0**										**5.6**		
Minneapolis	918	102	208	28.98	29.99	----	33.0	+0.6	62	1	41	7	29	25	28	----	----	----	0.65	-0.5	6	9,069	nw.	33	n.	6	4	13	13	6.5	3.2	0.0
St. Paul	837	236	261	29.06	29.98	-.08	32.2	-0.3	62	1	40	6	29	24	29	----	----	----	0.75	-0.6	4	9,755	nw.	38	nw.	1	4	15	11	6.5	2.7	T.
La Crosse	714	11	48	29.19	29.98	-.09	36.0	+0.8	71	5	44	9	29	28	29	----	----	----	1.19	-0.3	6	4,703	w.	20	w.	1	9	3	18	6.7	0.2	0.0
Madison	974	70	78	28.95	30.03	-.03	36.0	+0.8	71	5	44	8	29	28	32	32	28	75	2.59	+0.8	9	7,574	nw.	32	s.	11	5	10	15	6.8	2.6	0.1
Wausau	1,247	4	----	28.61	29.98	----	31.6	----	67	5	39	8	28	24	30	----	----	----	2.19	----	11	----	w.	----	----	----	6	6	18	6.7	4.6	2.3
Charles City	1,015	10	49	28.92	30.03	-.05	35.4	+2.4	70	1	44	6	29	26	32	30	26	75	0.66	-0.7	5	5,563	nw.	23	nw.	21	10	9	11	5.5	T.	0.0
Davenport	606	71	79	29.38	30.05	-.03	40.6	+1.6	76	1	49	6	29	32	33	36	31	71	0.60	-1.2	8	5,729	nw.	25	s.	11	12	6	12	5.3	0.5	T.
Des Moines	861	84	97	29.12	30.05	-.03	40.4	+2.0	74	1	51	8	29	30	36	35	30	69	0.53	-1.0	3	5,949	nw.	27	sw.	10	9	10	11	5.4	0.3	0.0
Dubuque	700	81	96	29.24	30.01	-.06	38.4	+1.4	74	1	47	9	29	30	31	33	28	71	0.56	-1.2	7	5,368	nw.	27	sw.	5	7	9	14	6.5	0.6	0.0
Keokuk	614	64	78	29.39	30.08	-.01	43.4	+2.3	79	5	53	10	29	34	39	37	31	67	0.50	-1.4	5	6,929	w.	34	nw.	21	9	10	11	5.4	T.	0.0
Cairo	358	87	93	29.74	30.13	+.01	49.6	+2.3	78	4	59	26	29	41	34	42	36	66	1.81	-2.2	4	6,911	s.	36	s.	6	12	9	9	4.8	T.	0.0
Peoria	609	11	45	29.40	30.08	-.01	41.2	+3.7	75	5	51	10	29	32	34	36	32	75	0.52	-2.1	6	6,054	s.	25	w.	21	12	10	8	4.5	0.2	0.0
Springfield, Ill	636	10	91	29.38	30.07	-.03	43.2	+1.0	76	5	52	14	29	34	36	38	33	74	1.74	-0.9	7	6,870	s.	30	w.	21	13	6	11	5.3	T.	0.0
Hannibal	534	74	109	29.51	30.09	.00	45.0	+2.9	82	5	55	12	29	35	38	----	----	----	1.14	-0.8	6	7,637	sw.	35	s.	11	14	9	7	4.2	T.	0.0
St. Louis	568	265	303	29.48	30.09	-.01	47.6	+2.5	77	3	56	20	29	39	35	40	33	63	1.53	-1.4	7	11,015	s.	52	sw.	5	15	8	7	4.5	1.1	0.0
Missouri Valley							**42.0**	**+3.2**										**65**	**0.80**	**-0.4**										**4.3**		
Columbia, Mo	784	11	84	29.24	30.10	+.01	45.9	+2.6	80	6	56	13	29	36	38	----	----	----	1.50	-0.8	7	7,101	s.	38	nw.	21	14	12	4	3.8	1.9	0.0
Kansas City	963	161	181	29.03	30.09	.00	46.7	+3.0	81	3	56	19	29	37	35	40	33	64	1.16	-0.7	6	9,072	s.	42	nw.	23	15	10	5	3.7	0.2	0.0
St. Joseph	967	11	49	29.01	30.07	----	44.9	----	81	3	55	16	29	35	33	38	31	66	1.04	----	5	6,799	nw.	38	nw.	21	17	9	4	3.3	1.0	T.
Springfield, Mo	1,324	98	104	28.69	30.12	+.02	48.5	+2.8	77	6	58	20	29	39	37	40	34	67	1.71	-0.9	6	8,415	s.	35	s.	5	18	8	4	3.2	T.	0.0
Iola	984	11	50	29.03	30.10	+.01	47.4	+4.4	82	3	59	20	29	35	41	----	----	----	2.24	+0.9	3	5,611	s.	27	s.	5	20	5	5	2.8	T.	0.0
Topeka	987	92	107	----	----	----	46.2	+3.4	84	3	58	18	29	35	38	----	----	----	0.88	-0.4	4	8,089	nw.	40	nw.	21	18	7	5	3.2	0.1	0.0
Drexel	1,299	10	54	28.64	30.05	----	39.2	----	75	1	50	9	29	28	39	----	----	----	0.14	----	3	8,034	nw.	34	nw.	21	9	13	8	5.2	0.3	0.0
Lincoln	1,189	11	84	28.78	30.08	.00	42.6	+3.5	76	1	54	13	29	31	42	34	27	62	0.42	-0.4	3	8,035	s.	46	nw.	23	8	10	12	5.6	0.7	0.0
Omaha	1,105	115	122	28.86	30.08	.00	42.0	+3.5	78	1	52	14	29	32	35	35	27	60	0.36	-0.7	5	6,520	nw.	44	nw.	23	12	11	7	4.9	0.2	0.0
Valentine	2,598	47	54	27.31	30.08	.00	37.6	+3.0	70	1	50	15	13	25	44	30	24	66	0.30	-0.4	5	7,932	w.	38	nw.	20	13	11	6	4.3	5.5	0.0
Sioux City	1,135	94	164	28.82	30.07	-.01	38.4	+3.2	73	1	48	12	29	28	39	33	25	63	0.02	-1.0	2	9,182	nw.	46	nw.	20	7	15	8	5.3	0.2	0.0
Huron	1,306	50	74	28.64	30.07	-.01	34.4	+2.9	62	18	46	10	28	23	44	28	23	69	0.12	-0.5	1	7,619	nw.	40	nw.	23	10	15	5	4.8	1.6	0.0
Pierre	1,572	70	75	28.37	30.07	-.01	37.5	+3.9	63	4	48	14	13	27	37	31	26	69	0.44	0.0	6	7,267	nw.	40	n.	23	12	8	10	4.9	5.2	0.0
Yankton	1,233	49	57	28.71	30.06	-.02	37.4	+2.1	71	1	49	11	29	26	45	----	----	----	0.48	-0.3	5	6,072	nw.	29	nw.	21	8	13	9	5.6	3.5	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, November, 1924*—Continued

Districts and stations	Elevation of instruments: Barometer above sea level	Thermometer above ground	Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Departure from normal	Days with 0.01, or more	Wind: Total movement	Prevailing direction	Maximum velocity: Miles per hour	Direction	Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Northern Slope							**34.2**	**+1.4**										**66**	**0.75**	**−0.1**										**5.3**		
Billings	3,140	5					36.0		79	2	49	−10	13	23	61				0.21		4		sw.				16	9	5		1.5	0.0
Havre	2,505	11	44	27.37	30.08	−.05	29.5	−1.7	59	29	39	−19	13	20	49	26	22	79	0.67	−0.1	4	6,154	sw.	37	sw.	20	9	9	12	5.7	6.7	0.0
Helena	4,110	87	112	25.84	30.15	+.05	32.6	−0.6	69	2	42	0	12	24	39	28	22	67	0.84	+0.1	9	5,255	sw.	50	sw.	22	7	10	13	5.8	6.2	1.2
Kalispell	2,973	48	56	27.01	30.15	+.08	31.1	−1.3	50	2	36	7	12	26	19	28	25	79	1.61	−0.3	12	3,104	nw.	38	sw.	20	3	8	19	7.8	5.6	0.0
Miles City	2,371	48	55	27.52	30.14	+.07	35.2	+4.3	59	18	45	−1	13	25	39	30	24	68	0.25	−0.4	5	4,989	nw.	36	nw.	22	10	11	9	5.2	1.1	0.0
Rapid City	3,259	50	58	26.62	30.12	+.04	38.9	+3.0	76	2	51	7	13	27	42	31	23	58	0.70	+0.2	6	6,159	w.	40	nw.	23	13	10	7	4.5	8.0	0.0
Cheyenne	6,088	84	101	24.02	30.09	+.02	38.5	+3.7	70	2	50	15	13	27	35	30	21	51	0.31	−0.1	4	11,329	w.	71	w.	20	12	8	10	4.8	3.2	T.
Lander	5,372	60	68	24.69	30.17	+.07	35.1	+4.8	68	3	48	6	13	22	34	27	20	62	0.09	−0.5	2	3,923	w.	58	sw.	8	14	14	2	4.2	0.9	0.0
Sheridan	3,790	10	47	26.14	30.13		34.6		77	2	47	−8	13	22	47	27	20	65	0.76		10	3,856	nw.	36	nw.	4	13	10	7	4.8	5.5	0.0
Yellowstone Park	6,241	11	48	23.94	30.24	+.13	27.1	−2.2	59	2	36	−2	13	18	28	23	18	71	2.23	+0.8	15	6,446	s.	40	s.	4	9	8	13	5.9	18.4	6.0
North Platte	2,821	11	51	27.14	30.13	+.05	39.6	+3.0	76	1	54	15	7	25	45	30	24	65	0.08	−0.3	4	5,442	nw.	40	nw.	23	15	7	8	4.4	0.8	0.0
Middle Slope							**46.5**	**+3.7**										**56**	**0.82**	**−0.2**										**3.4**		
Denver	5,292	106	113	24.76	30.08	+.02	44.4	+4.6	75	2	57	20	14	31	39	33	18	38	0.14	−0.4	2	5,390	s.	34	w.	27	16	13	1	3.2	2.8	0.0
Pueblo	4,685	80	86	25.34	30.09	+.04	43.0	+3.6	78	5	60	13	14	26	50	32	21	47	0.19	−0.2	2	4,567	nw.	37	nw.	22	16	14	0	3.3	1.8	0.0
Concordia	1,392	50	58	28.58	30.09	+.01	44.8	+3.4	77	5	57	20	29	32	39	36	28	61	0.38	−0.6	3	6,196	nw.	38	nw.	21	17	8	5	3.8	T.	0.0
Dodge City	2,509	11	51	27.49	30.14	+.07	45.9	+3.3	86	5	61	18	25	31	46	35	28	62	0.34	−0.2	1	6,610	nw.	34	nw.	26	21	5	4	2.6	T.	0.0
Wichita	1,358	139	158	28.63	30.09	+.01	48.1	+3.3	81	3	59	24	25	37	36	40	32	62	0.80	−0.4	3	9,952	s	50	s.	10	15	13	2	3.6	0.1	0.0
Broken Arrow	765	11	52	29.29	30.12		51.4		82	5	63	26	24	40	37				1.56		6	10,420	s.	48	s.	6	17	7	6	3.7	0.4	0.0
Muskogee	652	4					53.8		83	2	66	25	29	41	44				2.95		7		se.				13	11	6		T.	0.0
Oklahoma City	1,214	10	47	28.83	30.13	+.05	52.8	+4.0	84	5	64	28	27	41	37	44	37	63	3.04	+0.8	4	7,801	s.	34	nw.	6	16	10	4	3.3	0.0	0.0
Southern Slope							**55.9**	**+4.1**										**54**	**0.35**	**−0.8**										**3.2**		
Abilene	1,738	10	52	28.30	30.13	+.06	57.0	+3.5	85	5	70	26	24	44	41	46	38	58	0.02	−1.2	1	7,017	s.	34	n.	23	18	3	9	3.7	0.0	0.0
Amarillo	3,676	10	49	26.36	30.12	+.07	50.8	+5.3	84	5	64	25	27	37	38	40	32	59	1.25	+0.1	4	7,361	sw.	37	sw.	6	17	10	3	3.7	0.0	0.0
Del Rio	944	64	71	29.12	30.11	+.06	64.6	+4.6	84	6	75	34	28	54	37				0.01	−1.2	1	5,421	se.	37	n.	23	15	9	6	4.0	0.0	0.0
Roswell	3,566	75	85	26.45	30.09	+.06	51.2	+3.1	84	5	69	13	25	34	47	38	25	44	0.12	−0.8	1	5,150	s.	38	w.	6	26	4	0	1.3	0.0	0.0
Southern Plateau							**51.5**	**+2.2**										**43**	**0.13**	**−0.5**										**2.0**		
El Paso	3,762	110	133	26.28	30.05	+.05	56.4	+3.7	82	5	69	25	25	44	36	43	29	38	0.01	−0.6	1	6,246	nw.	37	w.	5	25	4	1	1.4	0.0	0.0
Santa Fe	7,013	38	53	23.32	30.11	+.08	41.3	+2.4	69	2	54	15	24	29	33	31	19	46	0.33	−0.4	2	4,872	n.	34	w.	6	20	7	3	2.6	T.	0.0
Flagstaff	6,907	10	59	23.43	30.11	+.09	37.8	+3.2	70	2	54	12	25	21	46	28		57	0.29		3	4,932	e.	44	e.	23	22	6	2		2.0	0.0
Phoenix	1,108	10	82	28.87	30.03	+.05	62.8	+3.1	96	2	80	34	25	45	47	48	36	46	T.	−1.0	0	2,832	e.	19	ne.	23	24	5	1	1.7	0.0	0.0
Yuma	141	9	54	29.88	30.04	+.06	62.9	+0.5	96	3	78	38	12	48	40	47	29	33	T.	−0.3	0	4,162	n.	30	n.	23	30	0	0	0.6	0.0	0.0
Independence	3,957	5	25	26.12	30.21	+.16	47.8	+0.6	77	3	62	23	7	33	39	35	19	37	0.33	0.0	1	4,776	nw.	47	n.	22	17	12	1	3.6	0.0	0.0
Middle Plateau							**39.2**	**−0.1**										**56**	**0.65**	**−0.2**										**3.4**		
Reno	4,532	74	81	25.59	30.19	+.80	41.4	+0.4	74	21	54	20	13	28	40	34	25	56	0.55	−0.1	1	3,903	w.	44	w.	9	15	12	3	3.3	T.	0.0
Tonopah	6,090	12	20				41.1		67	3	49	12	13	33	22	31	16	40	0.01		1		se.								T.	0.0
Winnemuca	4,344	18	56	25.76	30.24	+.10	37.3	−1.1	72	3	52	8	27	22	46	30	22	61	0.32	−0.4	2	5,745	ne.	40	sw.	9	13	6	11	4.8	0.6	0.0
Modena	5,479	10	43	24.74	30.20	+.12	36.7	+0.3	72	2	53	8	6	20	46	28	20	60	0.44	−0.2	2	6,090	w.	39	n.	22	21	7	2	2.4	1.5	0.0
Salt Lake City	4,360	163	203	25.77	30.21	+.09	40.4	−0.7	68	2	48	20	13	33	22	34	27	62	1.54	+0.1	5	4,109	nw.	37	n.	5	18	1	11	4.3	8.5	0.0
Grand Junction	4,602	60	68	25.52	30.17	+.09	40.0	+0.7	69	5	52	17	26	28	33	32	24	58	0.40	−0.2	4	3,379	se.	38	sw.	5	23	6	1	2.4	T.	0.0
Northern Plateau							**38.5**	**−0.9**										**73**	**1.66**	**+0.3**										**6.6**		
Baker	3,471	48	53	26.57	30.22	+0.6	36.2	+0.2	63	1	44	14	13	28	25	32	27	73	1.15	0.0	9	4,834	se.	30	s.	20	9	7	14	6.1	0.6	0.0
Boise	2,739	78	86	27.34	30.26	+0.9	40.7	−0.3	70	2	49	21	13	32	26	35	28	63	0.85	0.0	9	3,619	se.	34	w.	7	13	5	12	5.4	0.9	0.0
Lewiston	757	40	48	29.35	30.18	+0.6	41.4	0.0	59	20	48	23	30	34	22				2.42	+1.1	16	2,575	e.	30	w.	7	7	5	18	6.8	T.	0.0
Pocatello	4,477	60	68	25.61	30.23	+0.9	36.9	+0.2	71	2	47	14	13	27	31	31	24	64	0.53	0.0	6	7,555	s.	44	s.	9	9	11	10	5.7	0.5	0.0
Spokane	1,929	101	110	28.08	30.18	+0.8	36.0	−2.5	52	2	41	18	12	31	20	34	32	85	2.74	+0.4	16	4,193	sw.	27	s.	7	3	6	21	7.7	5.7	0.0
Walla Walla	991	57	65	29.10	30.20	+0.7	39.6	−3.2	62	19	44	24	13	35	30	37	34	80	2.25	+0.1	14	3,660	sw.	32	s.	7	4	5	21	7.9	1.3	0.0
North Pacific Coast Region							**45.7**	**−0.4**										**83**	**5.93**	**−0.7**										**7.3**		
North Head	211	11	56	29.83	30.07	+0.2	48.4	+0.2	61	27	53	36	12	44	18	45	41	79	5.37	−1.0	19	13,123	e.	78	s.	6	6	5	19	7.4	0.0	0.0
Port Angeles	29	8	53		30.07		42.6		56	20	48	30	13	37	17				4.69	+0.2	18	4,002	s.	26	n.	4	1	10	19		0.0	0.0
Seattle	125	215	250	29.97	30.10	+0.6	44.6	−1.0	59	29	50	31	12	40	21	42	39	82	4.84	−1.0	18	6,913	s.	50	sw.	19	4	8	18	7.3	T.	0.0
Tacoma	194	172	201	29.88	30.09	+0.5	43.8	−0.8	59	19	50	29	12	38	23				5.22	−1.4	19	5,424	s.	42	s.	7	2	10	18	8.0	2.5	0.0
Tatoosh Island	86	9	53	29.92	30.01	+0.4	45.8	−0.1	54	16	49	35	9	42	10	45	44	92	8.43	−3.7	18	16,381	e.	76	s.	4	3	5	22	8.1	T.	0.0
Yakima	1,071	5					37.3		59	20	46	20	27	28	29				2.08		12		sw.				6	13	11	6.2	0.7	0.0
Medford	1,425	4					44.5		76	1	54	25	26	35	33	41	36	78	3.15		12		w.				4	0	26		0.0	0.0
Portland, Oreg.	153	68	106	29.90	30.12	+0.2	45.6	−1.2	59	20	50	30	12	41	20	42	39	81	6.11	−0.3	16	5,127	e.	29	sw.	7	5	5	20	7.5	0.0	0.0
Roseburg	510	9	57	29.60	30.16	+0.4	46.2	+0.3	61	21	52	32	27	40	22	44	42	87	6.88	+2.5	16	1,924	s.	18	sw.	11	5	10	15	6.9	0.0	0.0
Middle Pacific Coast Region							**53.4**	**−0.3**										**76**	**2.48**	**−0.6**										**4.3**		
Eureka	62	73	89	30.09	30.16	+0.5	51.6	+0.5	69	1	59	36	29	44	30	48	46	85	6.37	+0.7	17	4,275	se.	27	s.	7	10	6	14	5.5	0.0	0.0
Point Reyes	490	7	18	29.56	30.08		54.8	+1.8	71	23	59	46	11	50	17				1.83		8	12,923	nw.	70	nw.	12	13	9	8	4.7	0.0	0.0
Red Bluff	332	50	56	29.78	30.15	+0.3	52.2	−1.6	71	15	62	34	10	42	36	47	57	69	1.69	−1.5	9	4,269	nw.	31	se.	7	16	8	6	3.7	0.0	0.0
Sacramento	69	106	117	30.07	30.14	+0.5	51.8	−1.8	71	3	61	35	27	43	29	48	44	74	1.59	−0.6	3	4,612	n.	35	nw.	22	17	9	4	3.9	0.0	0.0
San Francisco	155	208	243	29.97	30.14	+0.5	56.7	+0.4	73	22	63	46	11	50	22	51	46	74	1.50	−1.0	4	5,114	n.	32	n.	22	17	5	8	3.9	0.0	0.0
San Jose	141	12	110	30.00	30.15		53.4	−1.0	75	22	65	34	13	42	36				1.25	−0.6	3	3,917	s.	36	n.	23	14	8	8	4.3	0.0	0.0
South Pacific Coast Region							**59.5**	**+1.5**										**58**	**0.83**	**−0.4**										**2.8**		
Fresno	327	89	96	29.79	30.15	+0.9	55.1	+0.9	80	3	66	35	13	44	34	48	42	68	0.73	−0.3	1	3,081	nw.	27	nw.	10	20	7	3	2.9	0.0	0.0
Los Angeles	338	159	191	29.71	30.07	+0.5	64.1	+3.2	93	21	74	45	18	54	30	50	36	48	1.14	−0.3	3	3,546	ne.	20	ne.	12	23	6	1	2.3	0.0	0.0
San Diego	87	62	70	29.97	30.06	+0.4	60.0	+0.3	86	23	69	46	7	51	31	50	41	61	0.55	−0.3	3	3,698	nw.	23	w.	5	16	11	3	3.2	0.0	0.0
San Luis Obispo	201	32	40	29.90	30.12	+0.6	58.8	+1.5	88	2	73	35	7	45	47	47	38	57	0.89	−0.8	3	2,747	n.	27	ne.	22	19	9	2	2.9	0.0	0.0
West Indies																																
San Juan, P.R.	82	9	54	29.82	29.90		78.4	0.0	89	12	84	70	28	73	15				10.85	+4.0	20	6,419	e.	32	ne.	26	0	21	9	6.4	0.0	0.0
Panama Canal																																
Balboa Heights	118	7	97	29.74	29.86	+0.2	78.0	−1.1	88	18	84	69	10	72	16	74	73	92	12.63	+2.3	23	4,066	nw.	26	s.	5	0	9	21	8.0	0.0	0.0
Colon	36	7	97	29.83	29.86	+0.2	79.4	+0.2	90	1	85	73	5	74	16	75	74	91	30.29	+9.2	25	6,134	sw.	30	nw.	15	0	10	20	8.2	0.0	0.0
Alaska																																
Juneau	80	11	54				36.6		53	17	41	18	7	32	20	33	28	76	9.53		19	6,166	se.	54	e.	6	6	3	21	7.8	6.2	0.0

TABLE II.—*Data furnished by the Canadian Meteorological Service, November, 1924*

Stations	Altitude above mean sea level, Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*Inches*	*Inches*	*Inch*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	*Inches*	*Inches*	*Inches*
St. Johns, N. F.	125												
Sydney, C. B. I.	48	29.92	29.97	+0.02	39.8	+2.7	46.1	33.5	58	24	2.66	−2.78	2.0
Halifax, N. S.	88	29.87	29.98	−.03	41.0	+3.7	48.3	33.6	63	20	2.76	−2.90	3.9
Yarmouth, N. S.	65	29.87	29.94	−.08	42.0	+2.1	48.1	35.9	62	25	2.40	−2.16	1.0
Charlottetown, P. E. I.	38	29.88	29.92	−.04	39.6	+4.1	45.4	33.9	58	24	1.21	−2.76	5.2
Chatham, N. B.	28	29.82	29.85	−.12	34.2	+3.2	41.8	26.6	61	6	2.20	−1.55	8.8
Father Point, Que.	20	29.84	29.86	−.10	29.9	+1.0	36.4	23.3	57	2	2.28	−0.83	14.2
Quebec, Que.	296	29.61	29.95	−.07	33.8	+4.8	38.9	28.7	60	10	3.44	−0.32	9.9
Montreal, Que.	187	29.73	29.94	−.09	35.8	+4.0	42.0	29.6	63	6	3.87	+0.13	5.3
Stonecliffe, Ont.	489												
Ottawa, Ont.	236	29.68	29.95	−.07	35.6	+3.9	43.2	28.1	68	5	1.67	−0.87	4.1
Kingston, Ont.	285	29.68	30.00	−.04	38.5	+3.5	44.7	32.3	61	10	1.97	−1.27	0.6
Toronto, Ont.	379	29.58	30.00	−.04	39.0	+3.4	46.2	31.8	68	13	0.95	−2.19	1.1
Cochrane, Ont.	930												
White River, Ont.	1,244	28.50	29.85	−.13	20.9	+0.4	28.6	13.3	53	−25	1.93	+0.08	17.6
Port Stanley, Ont.	592												
Southampton, Ont.	656												
Parry Sound, Ont.	688	29.22	29.93	−.08	34.2	+2.1	40.4	28.0	66	3	3.98	−0.39	22.4
Port Arthur, Ont.	644	29.19	29.92	−.08	27.2	+3.2	32.1	22.4	54	2	0.70	−0.63	2.9
Winnipeg, Man.	760												
Minnedosa, Man.	1,690	28.10	29.99	−.05	17.4	+0.1	24.5	10.4	39	−11	0.80	−0.20	8.0
Le Pas, Man.	860												
Qu'Appelle, Sask.	2,115	27.66	29.99	−.01	21.1	+2.3	28.5	13.7	48	−14	0.94	+0.06	7.8
Medicine Hat, Alb.	2,144	27.65	29.97	−.03	27.0	−0.4	25.5	18.5	58	−12	0.60	−0.32	6.0
Moose Jaw, Sask.	1,759												
Swift Current, Sask.	2,392	27.43	30.05	+.03	23.4	+0.2	32.2	14.7	52	−16	0.98	+0.29	9.8
Calgary, Alb.	3,428												
Banff, Alb.	4,521	25.35	30.09	+.13	22.1	−3.7	29.5	14.7	42	−15	1.00	−1.27	10.0
Edmonton, Alb.	2,150	27.61	29.96	−.01	22.1	−0.8	29.1	15.2	49	−18	0.69	+0.11	6.5
Prince Albert, Sask.	1,450	28.40	30.03	.00	19.5	+4.1	28.2	10.8	44	−10	0.61	−0.22	5.9
Battleford, Sask.	1,592	28.20	30.01	−.01	21.7	+5.4	29.8	13.6	48	−8	0.92	+0.34	9.2

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St. Johns, N. F.	125	29.62	29.76	−0.15	45.4	0.0	51.4	39.5	68	30	5.84	+0.49	0.0
Sydney, C. B. I.	48	29.90	29.95	−.01	47.8	+1.3	54.9	40.7	72	28	2.38	−2.31	0.0
Calgary, Alb.	3,428	26.30	29.87	−.08	45.4	+5.3	59.7	31.2	74	19	0.94	+0.46	6.0
Kamloops, B. C.	1,262	28.63	29.92	−.04	50.1	+3.1	59.5	40.7	70	27	0.35	−0.26	0.0
Barkerville, B. C.	4,180	25.51	29.80	−.14	38.6	−1.1	46.0	31.3	58	15	3.16	+0.46	13.2

26176—25†——4

Chart I. Tracks of Centers of Anticyclones, November, 1924. (Inset) Departure of Monthly Mean Pressure from Normal
(Plotted by Wilfred P. Day)

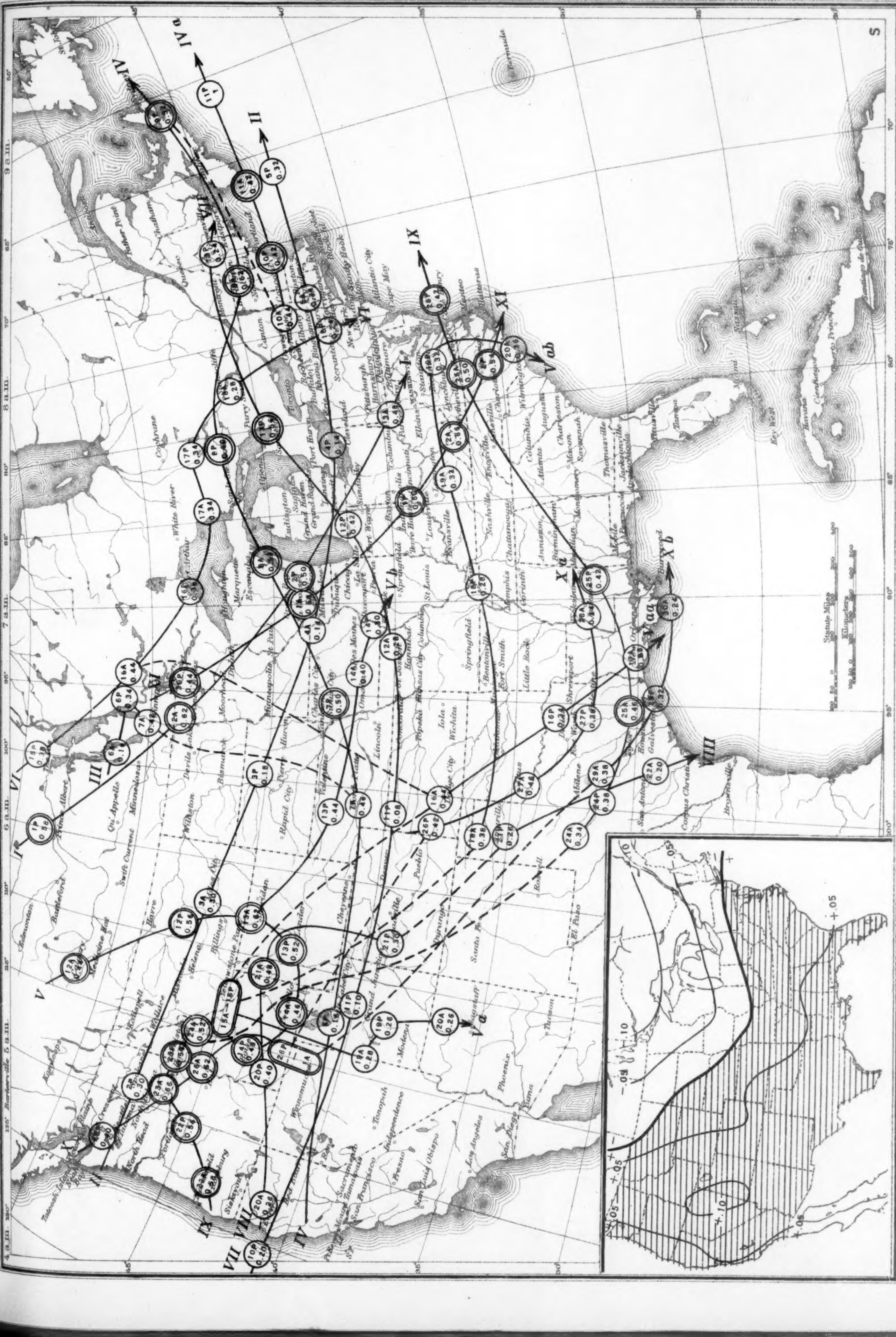


Chart I. Tracks of Centers of Anticyclones, November, 1924. (Inset) Departure of Monthly Mean Pressure from Normal
(Plotted by Wilfred P. Day)

Chart II. Tracks of Centers of Cyclones, November, 1924. (Inset) Change in Mean Pressure from Preceding Month
(Plotted by Wilfred P. Day)

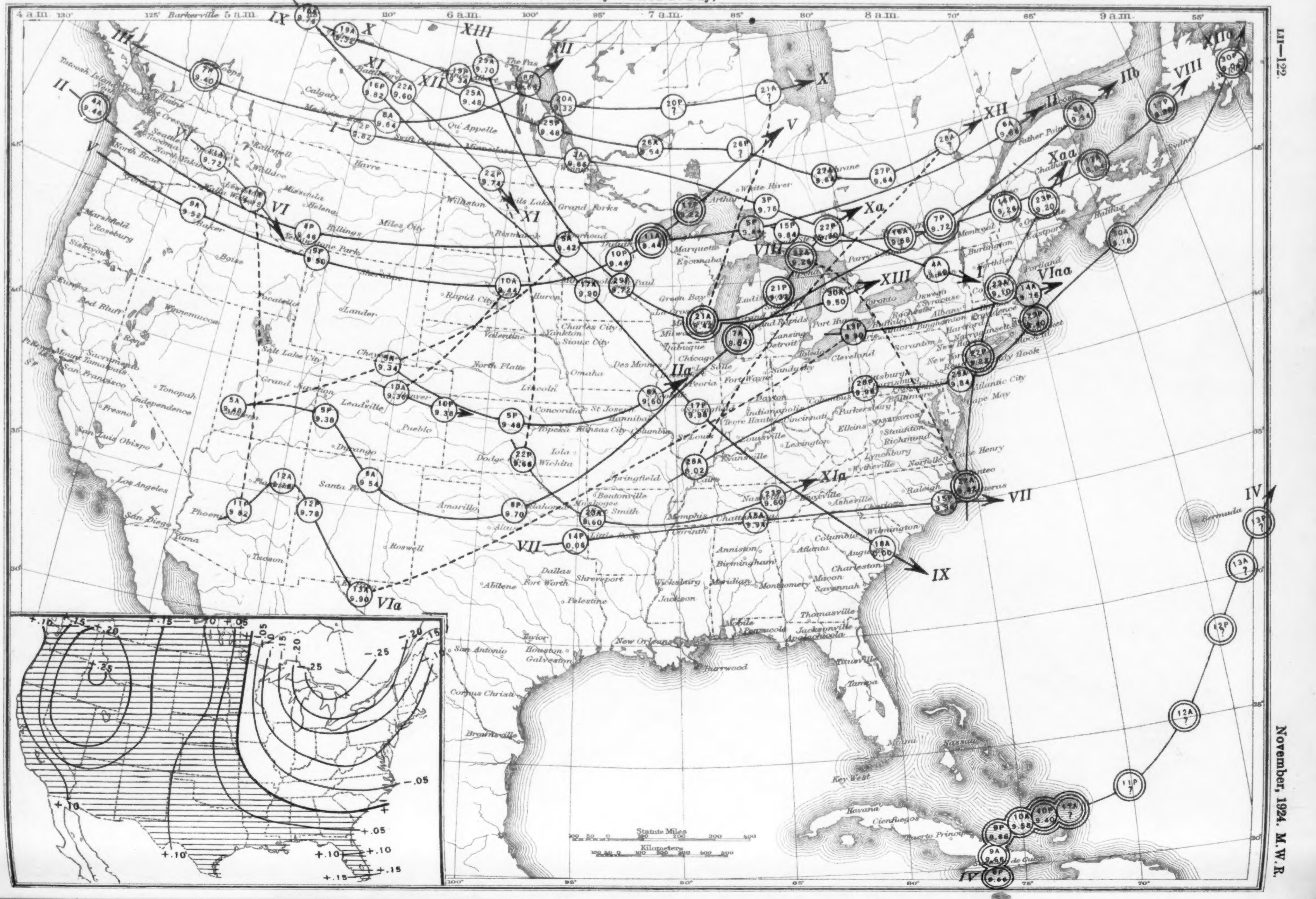
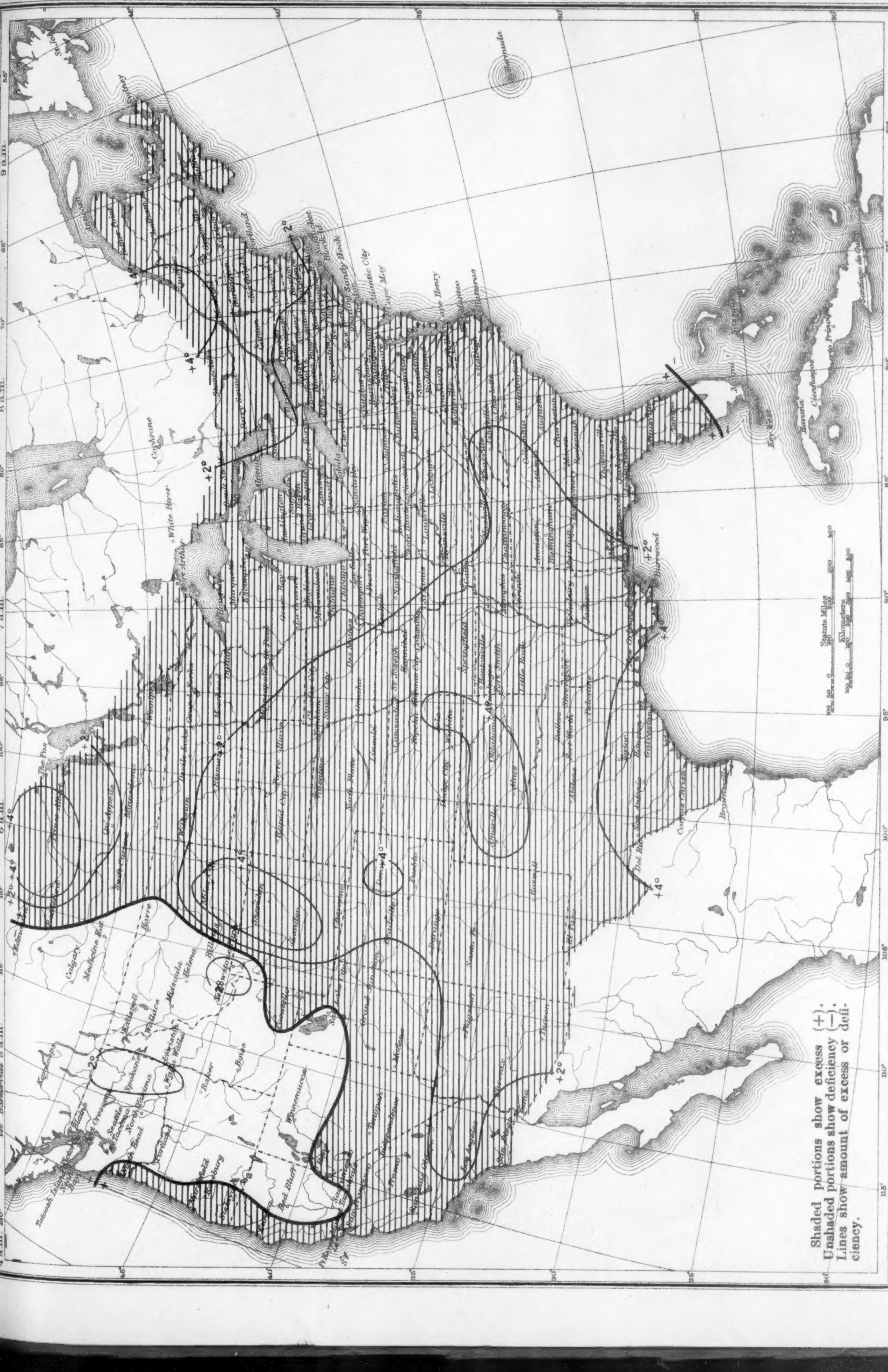


Chart III. Departure (°F.) of the Mean Temperature from the Normal, November, 1924

Chart III. Departure (°F.) of the Mean Temperature from the Normal, November, 1924



Shaded portions show excess (+).
Unshaded portions show deficiency (−).
Lines show amount of excess or deficiency.

Chart IV. Total Precipitation, Inches, November, 1924. (Inset) Departure of Precipitation from Normal

Chart V. Percentage of Clear Sky between Sunrise and Sunset, November, 1924

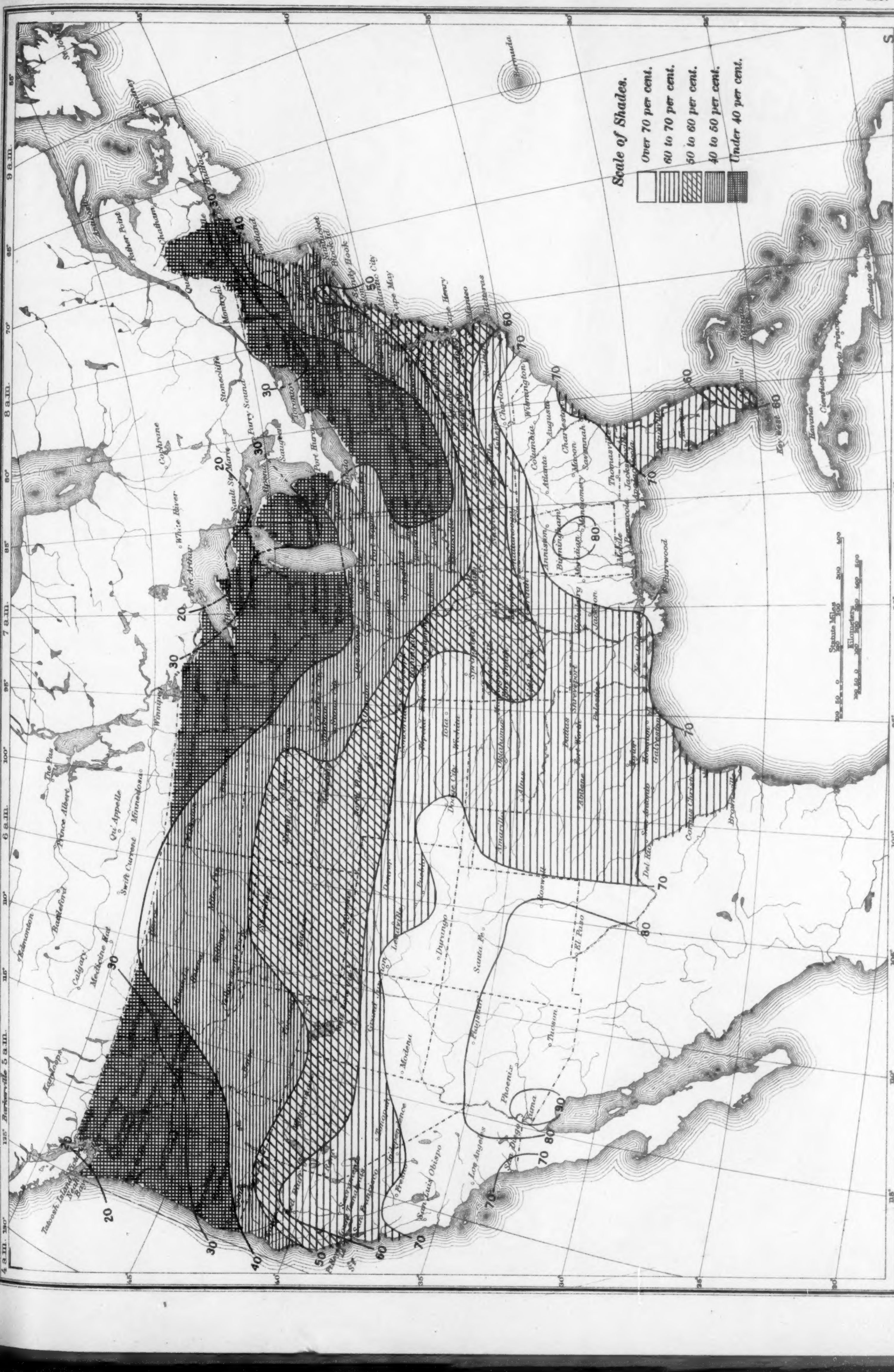


Chart V. Percentage of Clear Sky between Sunrise and Sunset, November, 1924

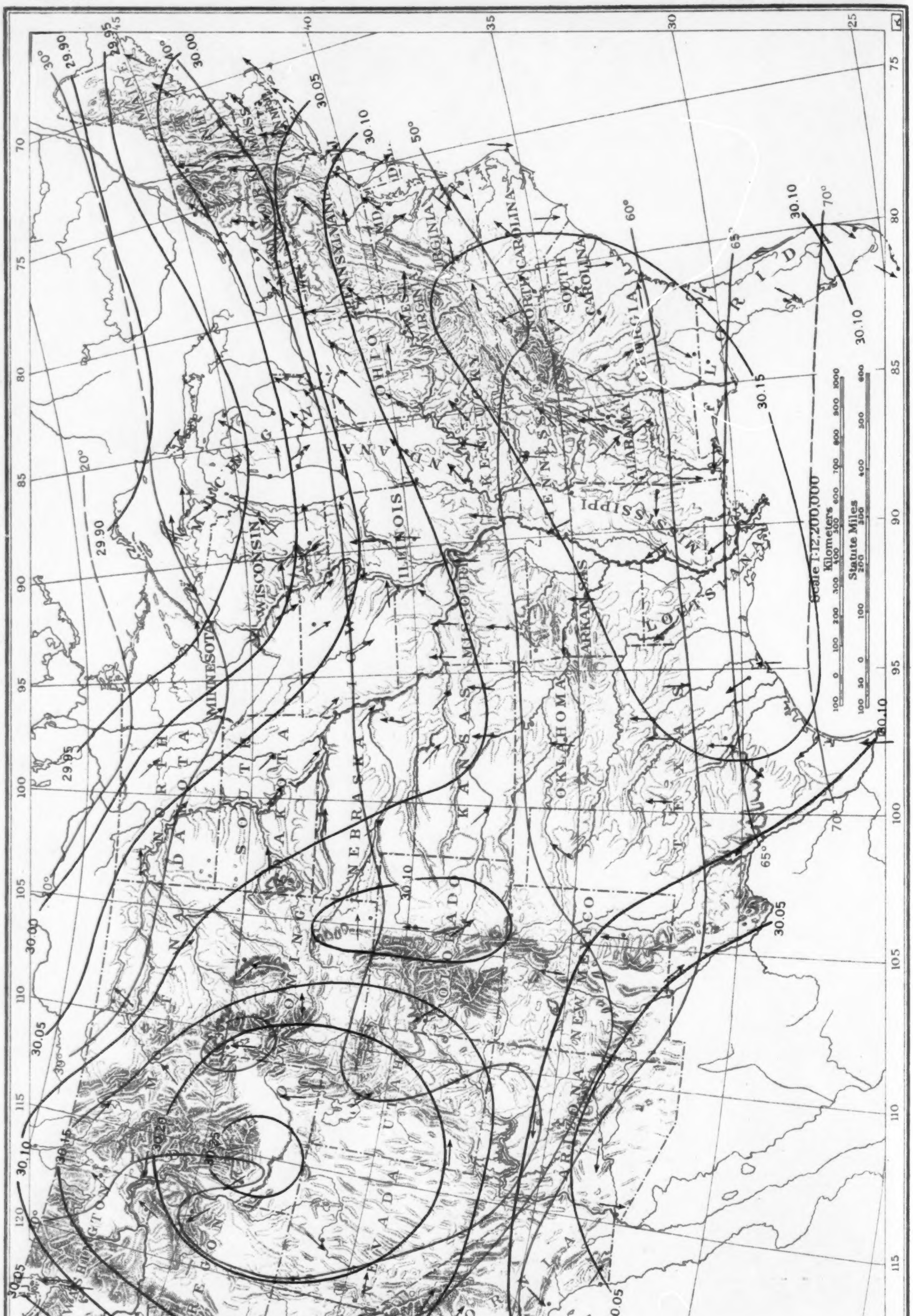


Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, November, 1924

Chart VII. Total Snowfall, Inches, November, 1924. (Inset) Depth of Snow on Ground at end of Month

Chart VIII. Weather Map of North Atlantic Ocean, November 9, 1924
(Plotted by F. A. Young.)

Chart VIII. Weather Map of North Atlantic Ocean, November 9, 1924
(Plotted by F. A. Young.)

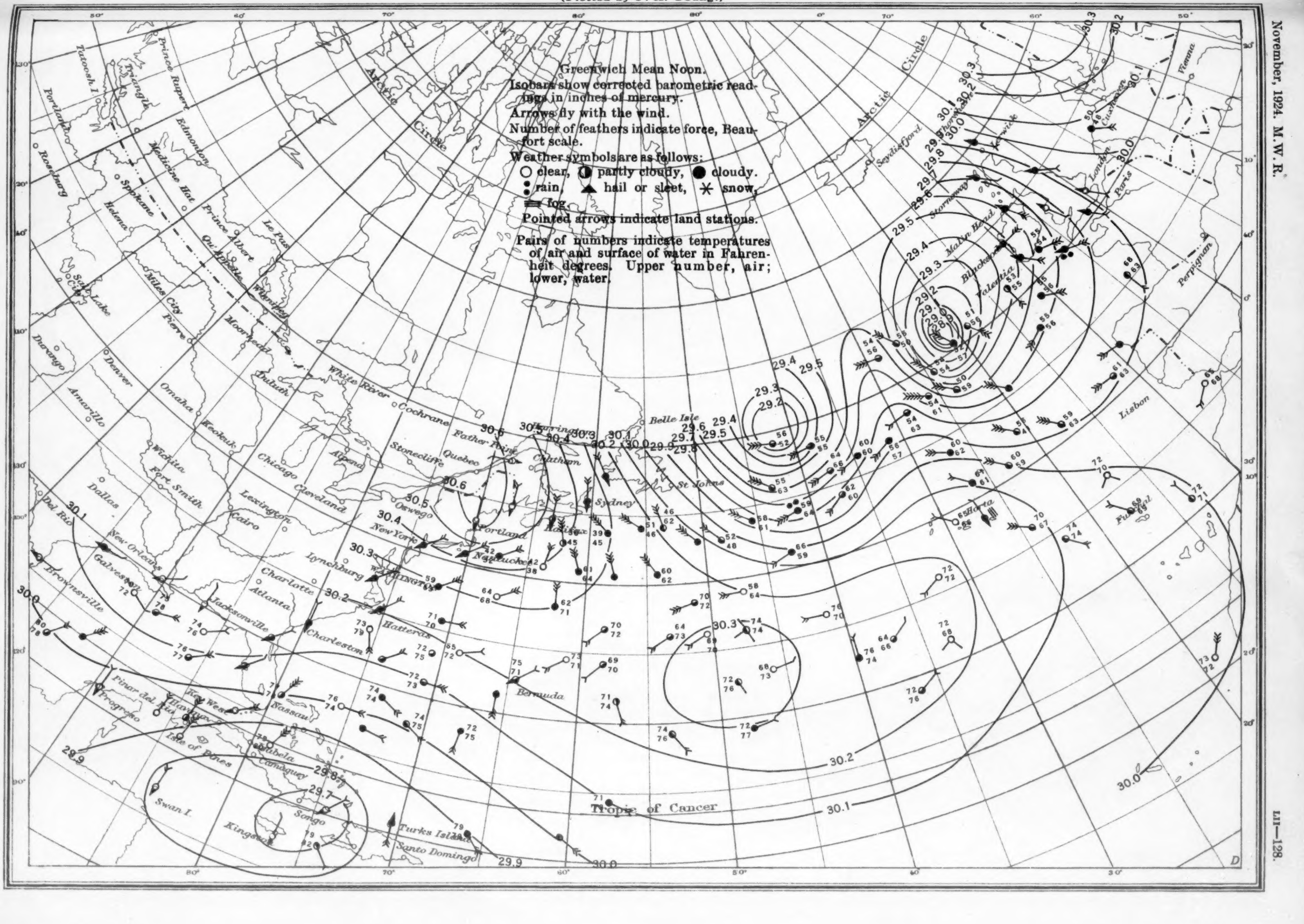
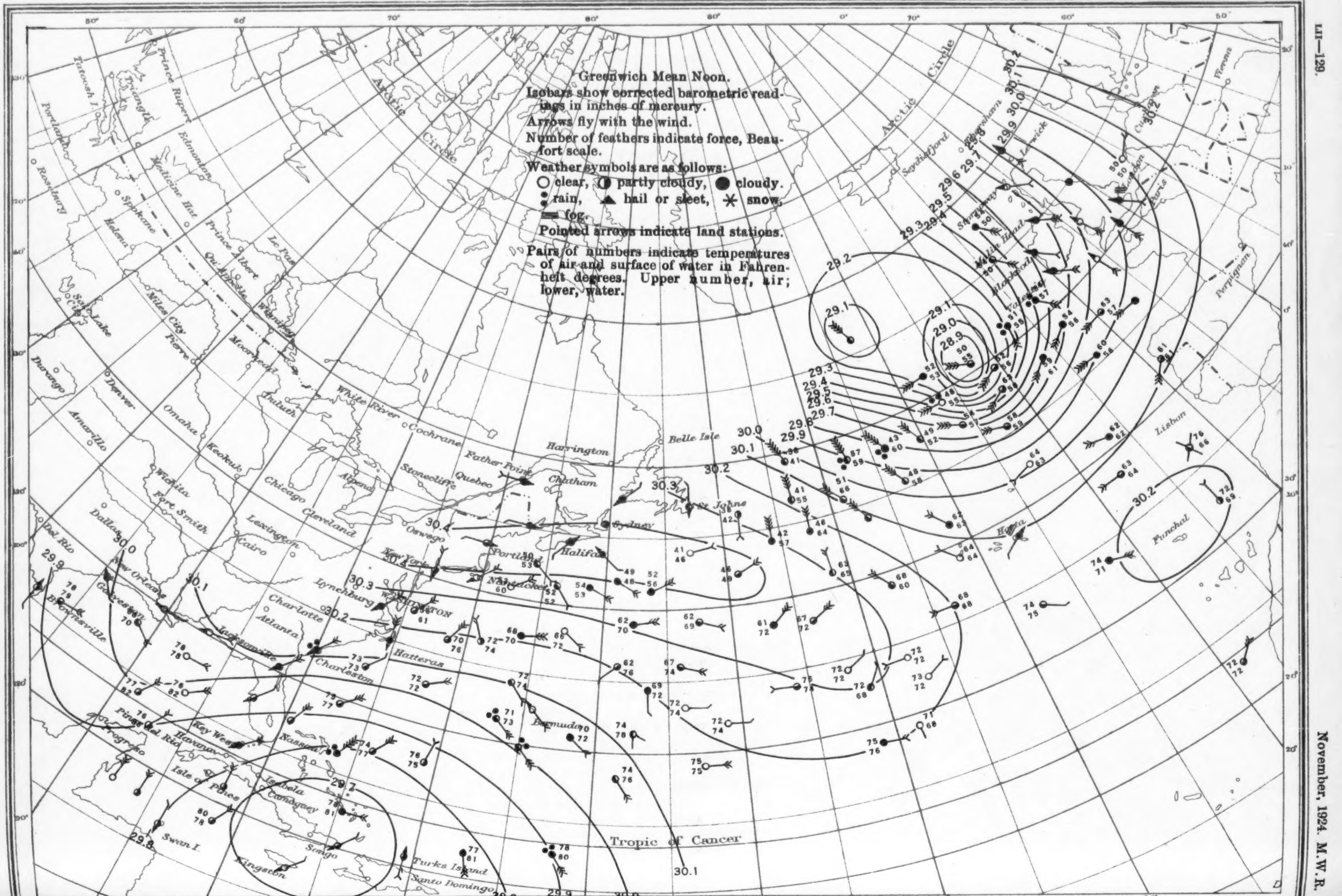


Chart IX. Weather Map of North Atlantic Ocean, November 10, 1924
(Plotted by F. A. Young.)



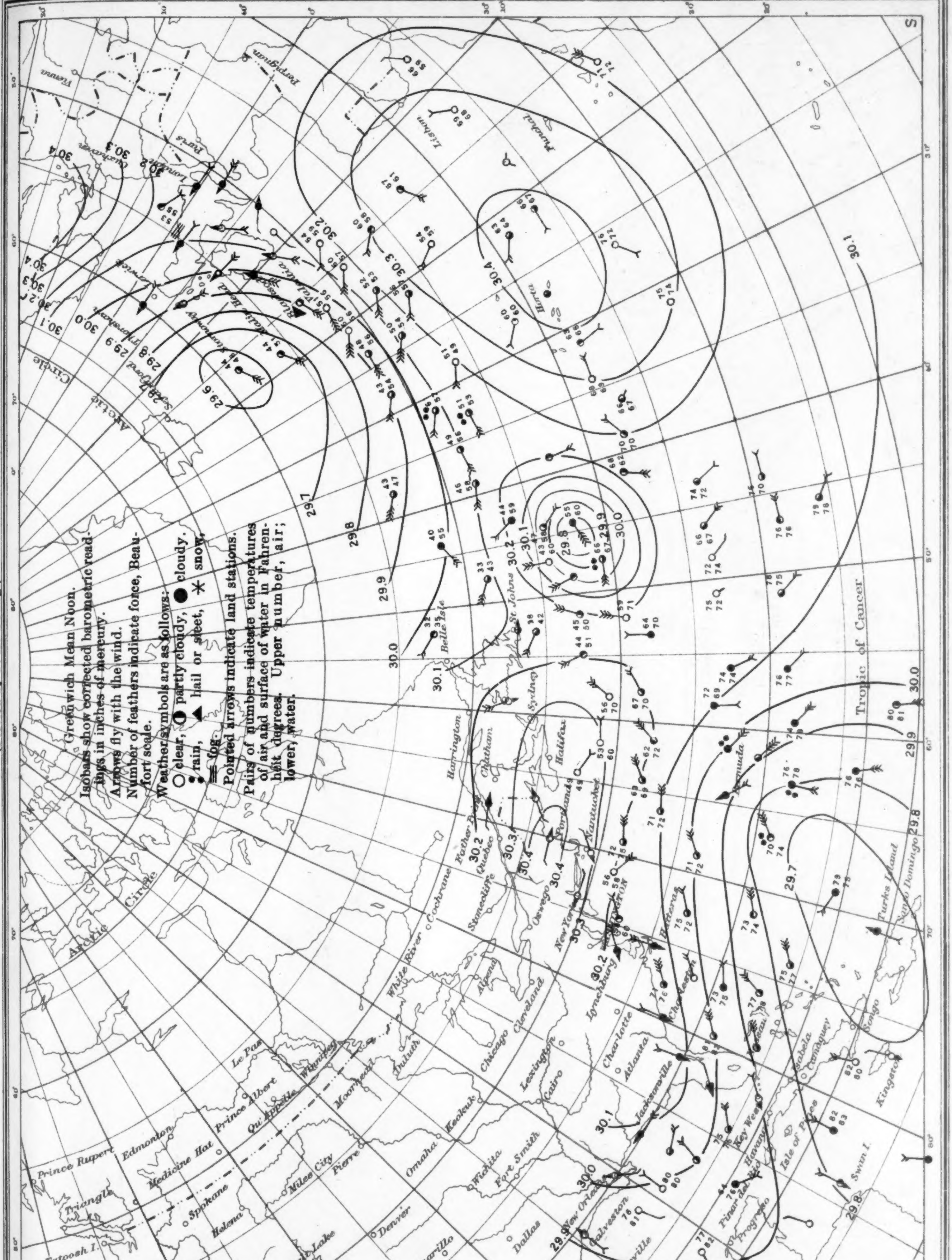
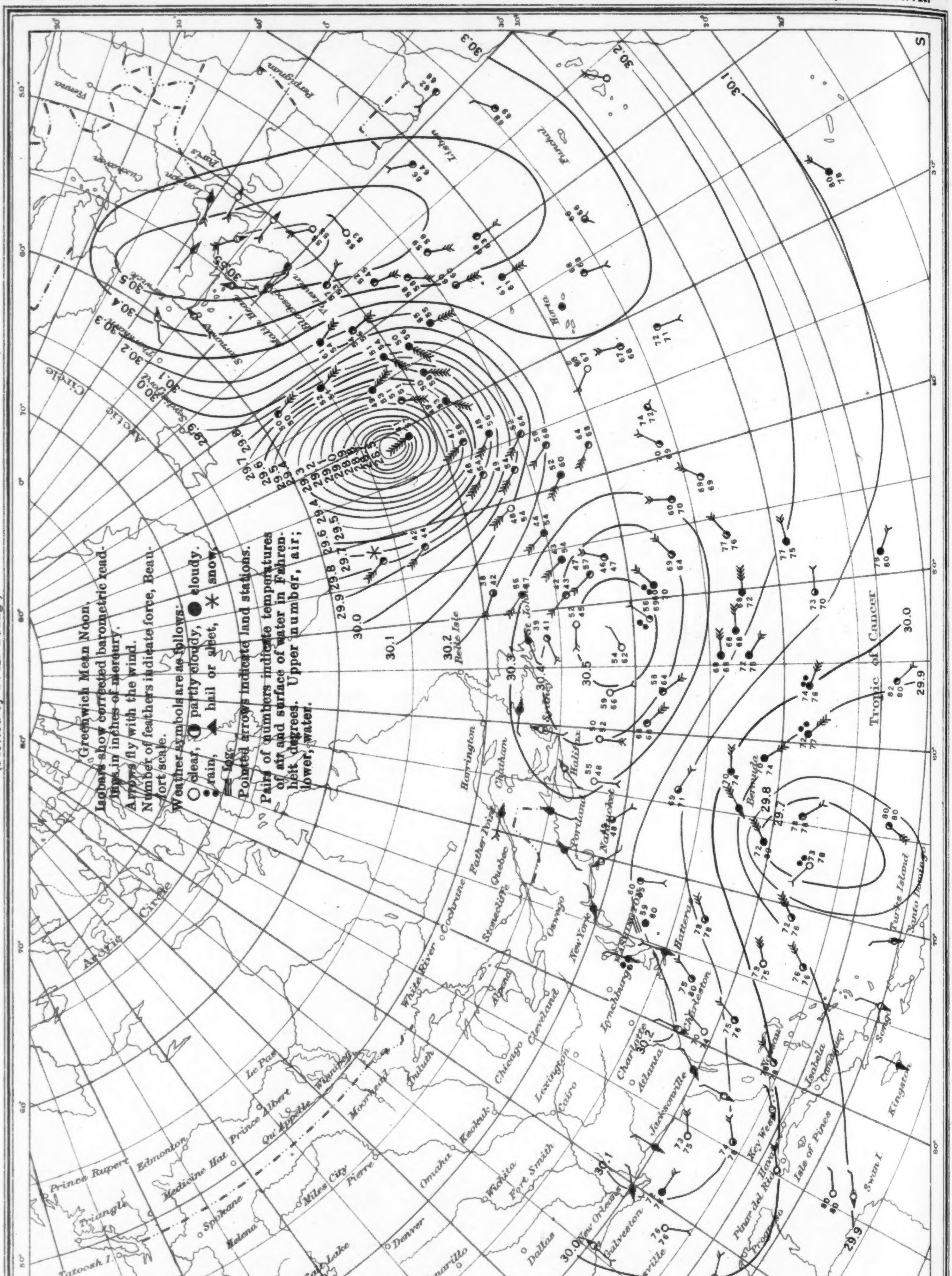


Chart X. Weather Map of North Atlantic Ocean, November 11, 1924
(Plotted by F. A. Young.)

Chart XI. Weather Map of North Atlantic Ocean, November 12, 1924
(Plotted by F. A. Young.)



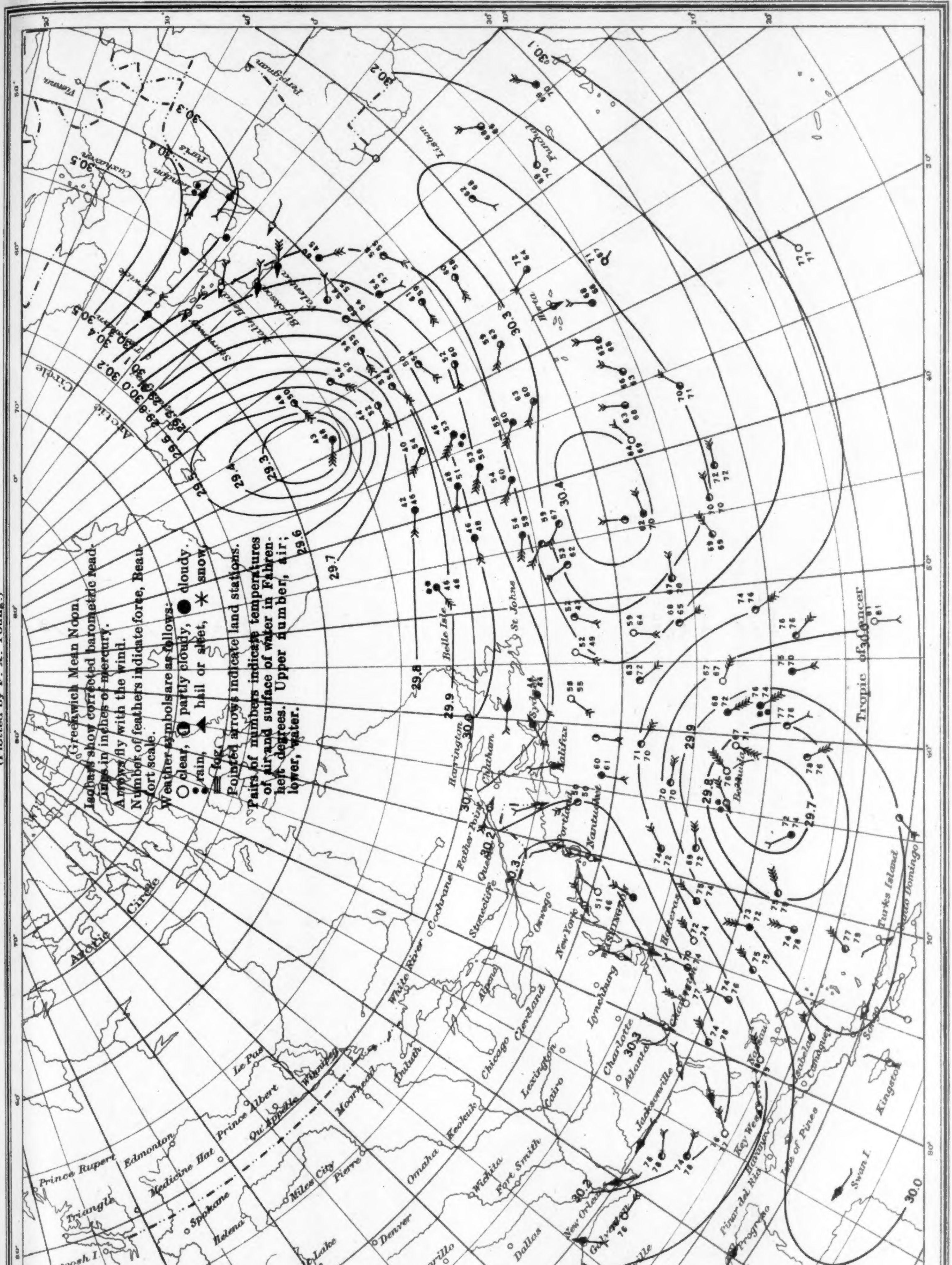


Chart XII. Weather Map of North Atlantic Ocean, November 13, 1924
(Plotted by F. A. Young.)

Chart XIII. Weather Map of North Atlantic Ocean, November 14, 1924

(Plotted by F. A. Young.)